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THE INCREASED CONFIDENCE IN AMERICAN RAILROAD SECURITIES.

By Thomas F. Woodlock.

FOR some years past attention has been given by investors to the fact that within a comparatively short time a large amount of American railroad bonds, bearing high rates of interest,—that is, six, seven, and eight per cent., and in a few cases even more,—would mature. Stockholders of roads on which large quantities of high-rate bonds were outstanding have naturally looked forward to the time when they could pay off these onerous loans, borrowing the money on better terms, but still leaving a mortgage on the property, or raising the necessary amount in other ways. The essential point in their minds, and in the minds of all who considered the matter, has been the fact that a considerable annual saving could be made by paying off the high-rate loans.

Within the last few weeks two great companies, the Lake Shore and the New York Central, have effected an operation by which they refund at three and a half per cent. all the funded debt now outstanding, consisting of high rate bonds, maturing at various dates in the near future. As the operations involve the issue of $150,000,000 of three and one-half per cent. bonds, and as the companies are among the most prominent in the country, it is only natural that the attention of everyone should have been attracted, not merely to the scheme in so far as it concerned these roads, but to the general principle underlying it and the possibilities of its application to other railroads. The announcement of the refunding plans caused at once the liveliest discussion of the position of other representative roads, and some interesting compilations were made, showing how the principal railroads of the country stood with regard to their bonded debt, and the possibili-

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ties of saving by the speedy replacement of high-rate bonds by bonds bearing a rate of interest commensurate with present monetary conditions. Perhaps the most perfect compilation of the kind was made by the *Commercial and Financial Chronicle*, which printed a list of railroad bonds maturing between now and 1905, amounting in the aggregate to more than seven hundred millions of dollars. These bonds now bear interest at rates from five per cent. upwards, and the *Chronicle* showed that, by refunding them on a four per cent. basis, the annual saving in interest would amount to no less than $16,678,690, while, if they were refunded at three and one-half per cent., the saving would be $20,232,138.

The whole subject is one of great interest and importance. It is evident, of course, that there has been everywhere a general appreciation of credit in the last few years. The process has been very marked in the case of British railroads. To mention one example, it is enough to say that only a little more than ten years ago London and Northwestern four per cent. debenture stock used to sell well below 120, whereas its present three per cent. debenture stock has been quoted at almost that price. Whatever appreciation has taken place in railroad credit here is to be accounted for, at least in part, by the general appreciation of high-class credit all over the world, but mainly, of course, by betterment in the position of individual railroads themselves.

A generation ago all our railroads had to offer very considerable inducements before they could secure the capital needed for construction or improvement. High rates for money had then to be offered, because of the highly speculative character of the undertaking, and because profits in all industries in those days were larger than they are now. The railroads had to borrow money at almost any rate, and only too often was it necessary to make large bonuses of stock to insure the placing of bonds. The high-rate bonds outstanding on our railroads to-day are a relic of the time when the building of railroads was as much a speculation as is a certain class of wild-cat gold mining to-day.

Many railroad systems of this country have passed through their time of trial, and now are recognized institutions of stability and value. Certainty of return therefrom places their securities on a high level in the eyes of investors, and what are known as "gilt-edged" mortgage bonds of a few railroads have for some time commanded high prices.

The Inter-State Commerce report for the year ending June 30, 1895, gives the following table of railroad bonds outstanding on which four per cent. interest or upwards was paid during that year. A large

number of bonds did not receive anything, and some received less than this, owing to the poor circumstances of the railroads themselves, pending re-organization, etc.

Bonds paying 4@5%,	$1,087,404,229
Bonds paying 5@6%,	990,957,044
Bonds paying 6@7%,	500,872,724
Bonds paying 7@8%,	343,493,020
Bonds paying more,	42,776,684
Total,	$2,965,503,701

Our railroads thus have an opportunity within the next few years —for long-term bonds were not fashionable when most of the high-rate bonds were put out—to pay off a very large amount of debt bearing high rates of interest. The great question is: On what basis can they borrow fresh money for this purpose?

In order to understand the rather peculiar position of our railroads, and thereby enable ourselves to answer this question, it is worth noting that in England debentures or obligations which are a first charge (or almost a first charge) on railroad property sell at pretty nearly one price, without much regard to the dividend paid by the road. The difference in yield between the debentures issued by a road which pays six or seven per cent. on its capital stock and those of a road which pays only about half this amount does not amount to much more than one-eighth of one per cent., the total yield to the investor varying from two and one-half per cent. to two and five-eighths per cent.

Here there is no such uniformity. Railroad bonds sell strictly according to the apparent general merits of the property which issues them, and yet very striking anomalies can almost always be found by taking a little trouble. A first-mortgage bond on an American railroad is not a security as yet of standard or fixed value, as is a debenture on a British road. In short, it is impossible to say that railroad credit in this country is on this, that, or the other basis of yield. The credit of Lake Shore and New York Central is seemingly on a three and one-half per cent. basis, but it is very doubtful if many other roads could be named whose credit is as high, and it would be still more difficult to give any one reason why the credit of a good many roads should not be as good in the eyes of the investor as that of these roads, as far as their first-mortgage bonds are concerned. The following considerations seem to bear upon the whole question:

(1) The railroad industry in this country has been, and still is, as it were, in a molten condition, although there are signs that it is finally settling into permanent shape. That it is not, as it is in Eng-

land, a solid, settled industry is obvious, and for a score of reasons. To mention one,—England was settled in every part before the railroads were built, while in this country the railroads practically settled the land. The railroads have been pioneers to a large extent, and, as they opened up fresh territory, conditions of population, commerce, and even daily existence changed, so that old methods, old principles, and old rules were of no use. There was never any equilibrium in the business of distribution and transportation, and it was obvious that there could not be, as long as railroad construction went on to a large extent year by year.

(2) Such conditions, or, rather, such change in conditions, completely upset original calculations, and brought carefully-constructed plans to nought, with the result that properties which seemed settled and prosperous were left high and dry by the changing tide of traffic under the influence of new territories opened up and new routes formed.

(3) In addition to all these things, the railroads have had to combat a process of continuous attack, first in the State legislatures, and finally in congress, which, as everybody knows, has had the effect at times of entirely demoralizing the conditions of business, without benefit to anyone but a few unscrupulous shippers and traffic managers. It is unnecessary to lay stress upon this aspect of the case, as a recent decision of the supreme court has brought it freshly before everyone's mind. This has hurt certain roads more than others, and thus has tended to accentuate already existing differences.

(4) Great Britain had its own experience of the railroad kings and the railroad wreckers, which was probably instructive, if short. Is it necessary to do more than allude to the part played in our railroad history by the promoter of railroad swindles of all kinds? One has only to look a little below the surface of the re-organizations of the last three years, completed and pending, to see the handiwork of the railroad thief in his various forms.

(5) The rarity of dividends on American railroad stocks has always stood as a warning to the careful investor in bonds. It has been, perhaps, one of the strongest factors making for the most careful discrimination on the part of investors as to the individual merits of each property. Naturally it has tended to prevent people in general from looking upon railroad mortgage bonds as of anything like uniform merit The natural effect of this has been to prejudice the good bonds, because the taint of those securities which were not good had to spread in some extent to all others. Default, occurring, as it has done, at short intervals, has acted as a perpetual deterrent to the investor in railroad bonds. Default on fixed obligations has been a great rarity in Great Britain these many years.

(6) Last of all, there are to be mentioned, of course, the unfortunate currency conditions that have existed in this country since the war. They are known to everybody. There is not the least doubt that these conditions have prevented railroad investments in this country from selling as high as they would otherwise have sold on their individual merits. Only of late years has the practice of making gold bonds become at all general, and, even in cases where gold bonds have been issued, there has often been question as to whether the railroad company would really fulfill its contract, in case the contract was of value only to the holder of the obligation. All of which has tended to foster discrimination.

These are a few of the reasons why the credit of our railroads has not been more uniform, and has not more nearly approached that of railroads in Great Britain and the other old countries. It is evident also that these are reasons for doubting that the rate of interest fixed by Lake Shore and New York Central in their refunding schemes is one that is likely to be attained by many roads in the very near future.

The fact of the matter is that our railroads have only just found what might be called a solid foundation on which they can build for the future. There is every reason to believe that decline in rates will be slower in the future, if it occurs at all, and that, unless there should be a fresh outburst of railroad construction,—which is not at all likely,—natural causes will shortly check it permanently. We have had for about four years a combination of panics, depression, and poor crops, which have severely tried every railroad in the country. It is not reasonable to suppose that, unless we are on the verge of a political and industrial revolution, the country will have to face such a combination of circumstances again for a long time.

Now, the point of this is that the principal railroads of the country have turned the corner. They may legitimately expect to do a larger business in the future than they have done in the last three years. Very few people, moreover, realize the extreme importance of the lessons of economy that have been learned by the railroads during this time of trouble. The whole railroad industry in this country may be said now to be, for the first time in its existence, upon something like a broad, solid, and scientific foundation. Honesty and efficiency of management are likely to show tangible results in the future.

It is evident from this that, as time goes on, there should be greater uniformity apparent in first-class American railroad credit. We may expect to see something like a standard, such as exists to all intents and purposes in England, and we should look for representa-

tive railroad bonds to conform rather closely to that standard. A settlement of our currency troubles would hasten immensely such a consummation, because it would effect direct connection between our investment markets and European capital, in place of the intermittent and altogether unsatisfactory connection that has existed for the last few years. These things, however, are matters that take time and hard work. Meantime bonds mature by the hundred million. What is the standard of credit to be?

If the line of reasoning adopted so far be correct, it is evident that it is not wise to attempt to fix a standard of credit now, for the future, by the issuing of very-long-term bonds at a rate sufficiently high to enable them to be floated at the present time. It is not by any means certain that many entirely solid roads whose bonds will mature in the next few years could refund them at the present time on a three and one-half per cent. basis. Probably a few could do so, but, on the other hand, many could not. It might be necessary for some roads to refund on a four per cent. basis, and even this might not suffice in the case of others. Is there not at least a good chance that ten years from now the credit of solid railroads in the country will be on a good deal better than a three and one-half or four per cent. basis? By that time, if the signs of the times are not deceptive, there will have gone on, in the case of all of our great systems, a process of steady growth and conservative upbuilding which will have had the effect of removing from the region of the speculative into the region of strict investment many securities now somewhat despised.

Hence, anticipation of maturity of bonds on the principle of the plans announced, by the issue of a long-term bond now on such terms as will induce existing owners of the high-rate bonds to convert before maturity, may not be, on the whole, a wise operation for other roads. Lake Shore and New York Central stockholders may some day regret that the directors placed a 100-year mortgage on the property bearing so high a rate as three and one-half per cent. It is possible that, when the great bulk of the outstanding sevens mature, these very three and one-half per cent. bonds may be selling on not far from a three per cent. basis. The possibilities, in fact, seem to lie chiefly on the side of an advance in railroad credit from its present level, and this is the chief argument against any hasty conversions before maturity. It is doubtful if anything will be lost by stockholders in any honestly-managed American road by waiting until almost the last moment before taking steps to refund maturing bonds.

The ideal position for stockholders of a railroad, as far as its bonds are concerned, is to have these bonds sell at not much above par, and the rate of interest paid should be such as to keep bonds about at this

level. Why should it be a source of gratification to the owners of a property to have its obligations quoted at high premiums, when this fact simply shows that the company is paying a higher rate of interest than it really needs to pay? This rather suggests a solution of the refunding difficulty which would, perhaps, secure to the owner of railroad properties the maximum of benefit from the refunding of their high-rate obligations.

Let a railroad company which has bonds maturing at intervals beginning next year go upon the principle of dealing with each batch as it comes due, on the best terms possible. Let it make one large refunding mortgage, designed to take the place of the maturing bonds, which mortgage should be made for a period of not more than twenty-five years. It should be made at no fixed rate of interest, but should be issued from time to time in the amounts required, at any rate of interest that might be determined upon by the directors. Thus the directors would be in a position to secure to the stockholders all the advantages arising from improvement in the credit of the property. As it would be necessary to issue some of these bonds in the near future, the advantage of placing stockholders in a position to revise the terms of interest on their obligations twenty-five years hence is obvious.

The making of long-term bonds—that is, for the periods longer than fifty years—has many and great disadvantages. The experience of British railroads with their irredeemable debentures and similar obligations selling at enormous prices with no possibility of relief to the stockholder is a warning in this respect. Credit generally is not going to depreciate much in the future, and American railroads seem on the eve of establishing their credit in the eyes of the world.

Ten or fifteen years ago London & North Western directors would have smiled, if anyone had told them that in 1897 their three per cent. obligations would sell at 118. They would have had more reason to smile than would directors in a good American road, if told to-day that ten years from now the credit of their road will be on a three per cent. basis. It does not do to neglect important possibilities for the sake of comparatively unimportant probabilities. The future seems to hold a great improvement in American railroad credit. Prudence dictates such present adjustment that full advantage can be reaped therefrom.

ELECTRIC TRACTION UNDER STEAM-RAILWAY CONDITIONS.

By Charles Henry Davis.

THE determination of the desirability or undesirability of substituting electric traction for steam on parts of some American railway systems is a matter of constantly increasing importance; and on many projected lines the question whether steam or electricity shall be used is a problem that must now be solved, although in the past there was no question as to which should be adopted. We shall probably see during the next ten years a large increase in the substitution of electricity for steam on railways. This change is foreshadowed by the present electrical equipment of elevated railways in Chicago; by the overhead trolley and third-rail experiments of the New York, New Haven & Hartford Railroad Company; by the operation of several branch lines of the Pennsylvania Railroad Company with electric motors; and by the present active discussions, among steam-railway engineers and managers, of the details of first cost, operating expenses, and methods of electric traction. The Illinois Central Railroad Company is again examining into the possible advantages of electric motor cars for its express and local suburban passenger business out of Chicago. They contemplated this change during 1892, but abandoned the idea as undesirable at that time. Their problem, together with the views of prominent electric manufacturing companies, is outlined in an interesting paper by John Findley Wallace, chief engineer of the road, read before the American Society of Civil Engineers (meeting of February 3, 1897).

The Pennsylvania Railroad and the New York, New Haven & Hartford Railroad have terminals, the first in Philadelphia, the second in Boston, where it would be desirable and interesting to study the relative merits of the two systems. Both points offer the greatest possibilities for the use of electricity, because of the large suburban passenger service requiring frequent trains over short distances.

In making a comparison of the use of steam locomotives and electric motors as motive powers, it will be found, in general, that, where the units of transportation are many, light, and frequent, and operated over short distances, the use of electricity will result in lower first cost and operating expenses, and will be more desirable in many ways; while with units that are few, heavy, and infrequent, and operated over long distances, the use of steam locomotives will result in lower

first cost and operating expenses, and prove more desirable. Though this general statement is often modified by special conditions, it will generally govern in determining changes from steam locomotives to electric motors, or the choice of one or the other in the case of newly-projected roads.

The subject can be treated under two heads: (*a*) new roads to be built; (*b*) old steam roads to be partially or entirely changed over. Having determined the factors that control the solution of any problem under (*a*), we can then discuss the additional conditions which should affect our conclusions when considering a problem under (*b*).

In either a new or an old line there is a limiting factor which sometimes precludes the possibility of using electric traction,—the transmission of electric power from the station to the motor. Some problems show at once that, owing to the long distance and infrequent trains of great weight, electric transmission of power would be entirely too costly. Just where the line occurs is hard to define, as it depends upon distance, amount of power, frequency of trains, and their weight. A few years ago it was considered that about ten miles' radius was the limit for one power house; this was before the days of "boosters" and multiphase currents. Without trying to define the exact limit beyond which electricity would be injudicious, we can state that, except for suburban traffic, and interurban traffic between towns a short distance apart, electric traction is to-day too costly both as to original investment and operating expenses. These facts cut out the freight business of steam railways, so that, should electricity be used for suburban passenger business, the local freight business would be handled by steam locomotives, which would also be used in other service. Express and mail business are not treated in this article. As suburban traffic can be considered to lie within twenty miles of the center of population (more often ten miles and never exceeding thirty), electric traction is always worth consideration. The present discussion is confined to these general principles and their limitation of the comparison between the two systems; in a second paper, to appear in the next issue of THE ENGINEERING MAGAZINE, we will consider the comparison in detail.

It is not the purpose in either article to give the actual costs and expenses, or their percentages, except when required to demonstrate a given point, but to show whether a given item will be relatively higher or lower in comparing the systems.

The reduction of first cost to a minimum consistent with work best suited for the purpose is of great importance in the construction of any line. No increase is justifiable, unless it will prove a profitable investment in itself; no decrease, however, is justifiable, if the larger

expenditure promises larger profit; where expenditures can be decreased, without materially lessening immediate traffic or adding to operating expenses, such decrease should be made. The importance of this is seen when we remember that the fixed charges (interest on bonds and rentals) are really a part of the cost of manufacturing transportation,—to borrow an expression from an eminent authority; they are, in fact, one of the largest items in the total cost of running a railway system; they increase in a somewhat faster ratio than the cost of the line, and are the same every year, whether business is good or bad; and we therefore emphasize the importance of reducing the first cost to the lowest amount consistent with true economy, and of increasing the traffic to its maximum, so that the fixed charges may be a smaller percentage of the gross receipts. It must be remembered, however, that the gross receipts are often enormously increased by extraordinary expenditures, in which case large investments may be warranted, such as terminals at or near large centers of population, shortening of line for moral effect and saving of time in competition, adopting new methods as an inducement to increased use, etc. An idea of the weight which should be given to this part of the subject will be had by the following comparison of steam-railway operations:

	Average.	High.	Low.
Per Cent. Operating Expenses	65	70	55
" " Net Receipts	35	45	30
" " Fixed Charges	25	45	14
" " Profit	10	16	4

Examining the above table, which is not supposed to show highest and lowest figures, but averages under ordinary conditions, we see the importance of the item of fixed charges, and the importance, therefore, of reducing first cost. It will be shown in these articles that the first cost of electric roads will almost always exceed the first cost of steam roads,—a decided disadvantage. In a few cases, however, electric roads will involve lower first cost,—namely, where the units are light and very frequent, and where the stops are very frequent; but, in general, the inducement to adopt electricity instead of steam, or to discard the latter, will be the increased travel which undoubtedly comes, in a greater or less degree, to roads using electric motors.

The fact that usually the first cost and the total expenses will be greater with electricity than with steam might lead us to discard the thought of using the former under any circumstances, were it not for the question: How will our gross receipts be affected by the use of one or the other system? Leaving for the second paper the demonstration of the comparative cost of installation and operation under each system, and accepting for the present the general conclusion that the showing on this side is against the electric system, we will pass to the

examination of the other side of the books. If by using electric traction we can sufficiently increase the gross receipts per car-or train-mile and per mile of road, we can afford to pay for the additional first cost and greater total expenses. This is the vital question and the real one at issue, although usually not so considered. Our discussion is limited to passenger receipts. Within the scope of a magazine article we can give only a general idea of the many elements which affect this question.

By examining statistics of steam railways we find that the volume of travel is influenced by such features as the following: convenient location of stations with respect to centers of population; length of line; proximity of terminals to the centers of population; number of trains; (the four points just mentioned have an overwhelming effect on short-haul traffic); good road-bed and track neatly kept; handsome commodious stations, with first-class appointments and service; comfortable and luxurious cars; block signals; cleanliness, etc. Profit is proportional to success in obtaining that travel which enables each train to run full, for the cost of a train-mile is not affected by the number of seats taken; and it is this travel which is obtained by a line giving weight to its "location" and "appointments." In freight competition between railways the rates are ultimately dependent upon the cost from "consignor to consignee," not from station to station, and the railroad eventually pays the additional cost of lighterage, switching, cartage, etc., and the profit thereon, whether by actual difference in rates or loss of business. The same is true in passenger traffic, as will be seen by free omnibuses, reduction in rates, etc. If you can take the passenger up at his own door and set him down at his place of destination, you have not only suited his convenience (and thus, as we shall see, induced him to travel oftener), but have secured those receipts which otherwise would have gone to omnibuses, hackmen, and street-car lines. This the steam railways have failed to do, and it is clear that they cannot altogether do away with these feeders natural to their peculiar modes and conditions of traffic; but there is little room to doubt that in many cases steam railways can modify their present methods, for surburban traffic out of large centers of population and for interurban passenger traffic on branch lines between centers of population, by the use of electricity, paying the additional first cost and greater total expenses out of the probable (we might say certain) enormous increase in their gross receipts. This, I believe, can be accomplished only by a radical change in the present methods of operation, making them approach, on parts of the system, the present "leave-at-your-door" plan of our street railways, while keeping, on the rest of the system, the present methods of

steam railways with possibly some minor modifications. To accomplish this to advantage, the use of electricity will probably prove advisable, although in some instances a combination of electricity with steam might give the best results. Let us consider some of the figures bearing on our problem.

The Pennsylvania Railroad originally spent about $5,000,000 for its Broad street terminal; the great St. Louis bridge and Union Station cost many more millions; while the Market street terminal of the Philadelphia & Reading Railroad, the Union Station of the Boston & Maine Railroad systems, the Southern Union Station of the New York, New Haven & Hartford Railroad in Boston, and the Grand Central Station in New York are proofs of the millions of dollars spent by railway companies to locate their terminals at or near the centers of population. These expenditures were incurred almost entirely for the sake of increasing the suburban passenger traffic, although giving a decided stimulus to through and competitive business. In my opinion, our steam-railway companies can afford to double (to use a broad and inaccurate expression) these investments to accomplish what has been suggested above, reaping a handsome return from the increased gross receipts from the passenger traffic now handled by electric street railways.

Taking the New England States as a basis for comparison,—for there we shall find the shortest hauls, the most dense population, and the greatest number of trains,—we glean from "Poor's Manual" the following figures:

STEAM RAILWAYS IN THE NEW ENGLAND STATES.

(Me., N. H., Vt., Mass., R. I., Conn.)

	1894.	1895.
Length of line operated (miles)	7,452	7,659
Passenger train mileage	31,097,374	30,266,737
Total passengers carried	128,545,855	116,069,178
Passengers carried per train-mile	4.13	3.84
" " one mile	1,842,924,000	1,856,263,668
Passenger earnings—total ($)	34,462,989	34,224,725
" " per passenger per mile (cents)	1.87	1.84
Passenger earnings, average total each passenger per trip (cents)	26.81	29.48
Passenger earnings, per train-mile (cents)	110.82	113.07
Passenger earnings, per mile of road ($)	4,625	4,468
Average number of passengers carried per mile of road	17,250	15,155
Average number of passenger-miles per train-mile	59.26	61.33
Average distance traveled per passenger	14.34	15.99

From statistics of street railways in New England operated exclusively by electricity, including all from which reliable data could be obtained, the writer has compiled the following tables:

ELECTRIC STREET RAILWAYS (1895) IN THE NEW ENGLAND STATES.

(Me., N. H., Vt., Mass., R. I., Conn.)

State.	Total No. of Roads in State.	No. of Roads Taken.	Total Length of Track.	Total Passengers Carried.	Total Passenger Receipts.($)
Maine....	14	9	89.43	8,963,387	478,959
N. H.....	5	3	44.00	3,299,115	161,271
Vt.....	5	—	—	—	—
Mass.....	64	37	612.69	74,241,633	3,692,843
R. I.	7	4	102.36	30,204,653	1,498,963
Conn.....	23	18	265.02	37,684,559	1,809,646
Totals..	118	71	1113.50	154,393,347	7,641,682

Length of track operated (miles)	1,113.5
Car mileage	—
Total passengers carried	154,393,347
Passengers carried per car-mile	—
" " one mile	—
Passsenger earnings—total ($)	7,641,682
" " per passenger per mile	—
" " average total each passenger per trip (cts.).	4.95
" " per car-mile	—
" " per mile of road ($)	6,862
Average number of passengers carried per mile of track	138,718
" " passenger-miles per car-mile	—
" distance traveled per passenger	—

It is regrettable that there are so many blanks in the above table. The exact car-mileage of electric roads for 1895 not being ascertainable at this writing, this item is necessarily omitted, as well as others depending upon it. But these figures are not essential to the purpose in hand. In comparing the two tables, we must remember that the steam roads include every road in the section, while many electric roads are omitted, and that, in the case of the steam roads, length of "line" is given, while, in the case of the electric roads, length of "track" is given. Therefore the following ratios, steam roads figuring as 1, are only approximate:

Length	1 to .14
Passengers carried	1 " 1.33
Total receipts	1 " .22
Receipts per passenger per trip	1 " .16
Receipts per mile	1 " 1.53
Number of passengers per mile	1 " 9.15

The average number of passengers per car-mile carried by the roads of Massachusetts in 1896 was about 6 (5.95). Statistics of all the

street roads in New England would show the number of passengers carried to be four times as great as the number carried by the steam roads. Assuming the same ratio between passengers and car-miles, there were 25,732,224 car-miles operated by the electric roads, standing to steam-road train-mileage as 1 to .71, or, assuming an average of 4.5 cars per train, as 1 to .15 car-miles. As it is impossible to determine the average length of passenger-trip on a street railway, we can never arrive at the receipts or cost per passenger-mile.

The characteristics brought out by these figures are the enormous number of passengers per mile, the large receipts per mile of road and per car-mile, and the greater total number carried, on electric roads. The steam road gets greater receipts per trip, but carries each passenger a longer distance, and has to run a disheartening number of cars or train-miles for the passengers carried. The difference is due to the short trips, high fare per passenger- and car-mile, and the "leave-at-your-door" service, of electric roads. As our argument is confined, for reasons stated, to surburban and interurban short hauls, we think it plain from what goes before that the adoption of electricity as a mode of operation, with the additional change to the prevailing methods of our present street railways giving nearly the same class of service, (combined or not with steam locomotives as the case may require), will result to the steam roads in an enormous increase of the total passengers carried, passengers per car-mile and rate received per mile, and will shorten the length each passenger is hauled; and, by thus increasing the gross receipts, will more than pay for the additional investment. If this cannot be done in any given case, then it will not pay to make the change.

The conclusion is that electric traction can be profitably used:

(1) Where units are so light and so frequent, and carried so short distances, that steam locomotives cannot be furnished at lower first cost or operated more cheaply, as in the plain case of a street railway;

(2) Where the gross receipts will be so increased by the change of system and the mode of operation as to more than pay for the increased first cost and operating expenses per car-mile, as in the case of suburban steam systems running out of our great cities and interurban systems between large towns situated a few miles apart;

(3) Where competition of parallel electric roads compels the change to save what traffic there is, irrespective of the question whether it will be more profitable;

(4) Where higher speeds are required than can be attained by steam locomotives. (This case has not been discussed in this article; it will be taken up in another paper.)

Should an existing line make the change, the item of loss from discarding old equipment, etc., must be taken into consideration; otherwise the problem remains the same. In many cases such equipment can be used on other parts of the system. Steam-railway managers should avoid making the mistake which took place in the change from horse traction to electric traction,—namely, of trying to reduce the first cost of changing by the use of old methods, material, and equipment, which, although entirely suited to the old system, proved most unsatisfactory under the new conditions. The old equipment partly made over will not do. There must be new trucks, and new and lighter car bodies, hung lower for greater ease of entrance and departure. Old methods of operation must be discarded, and new ones substituted. A change of system may necessitate additional tracks, which should be provided even at large cost. The nearer the approach to the "leave-at-your-door" service, the greater the success.

Let us consider some examples where it is probable that electricity could be substituted with profit, remembering that more thorough investigation might show, in this or that case, that the change is undesirable.

Suburban service of the Pennsylvania Railroad, out of Philadelphia, as follows:

P., W. & B.	Division to Wilmington.
Main Line	" " Paoli.
Germantown & Chestnut Hill	" " Chestnut Hill.
Reading	" " Norristown.
U. R. Rs. of N. J.	" " Tacony.
Westchester	" " West Chester.

By the use of multiphase current and rotary-transformer sub-stations, one power house, located conveniently on the Schuylkill river, could take care of such a system; from these sub-stations direct current at 500 volts would be fed into the trolley or third-rail line. The equipment should be entirely new; cars of the same seating capacity, but lower and of lighter construction, should be used; the bridge over the Schuylkill river into Broad Street Station should be widened by four additional tracks; main line and U. R. Rs. of N. J., by two tracks, each; P. W. & B. should have a total of four tracks; Germantown & Chestnut Hill, Reading, and West Chester should each have a total of three tracks; all tracks should be equipped electrically, although some of them would be used by steam locomotives hauling freight and through passenger trains, and some or all, at times, by both systems. Two tracks should be laid in the street from Broad Street Station to the Schuylkill bridge coming to railroad grade at that point; the cars running over these tracks should operate from the

Delaware river out Market street, by trackage arrangement with the street railway or by special franchise, the street being wide enough for four tracks; they should be run as any street-railway line is run to-day, and continue out on the extra tracks, provided above, as far as circumstances might warrant, and should be extended as travel required; right of way should be prepared, so that passengers could leave or enter these cars at any point along the line. Local stations should be provided, in some cases much closer than at present, at which passengers, on the cars mentioned above, could change to electric cars stopping only at said stations, or to express electric trains stopping at fewer points, all being done by the payment of a single fare. It will be seen that this is a combination of the street railway on the outside tracks with the local and express service of a steam road on the inside tracks, while the through locomotive trains operate on the middle tracks. The proposition is a radical one, is advanced as such, and will bear close investigation and study; the expense would be enormous, but the gross receipts from such a system of street railways, accumulating passengers for the rapid-transit system connected so intimately with it, would also be enormous,—in fact, I believe, far in excess of anything yet accomplished in transportation of passengers.

The same treatment of the following terminals, with modifications to suit each case, would be worth studying:

New York, New Haven & Hartford Railroad, out of Boston;
Boston & Maine, out of Boston;
Philadelphia & Reading, out of Philadelphia;
Harlem, New York Central & Hudson River, and New York, New Haven & Hartford Railroad Companies, out of New York city;
Central Railroad Company of New Jersey, out of Jersey City;
Illinois Central Railroad, out of Chicago.

It must not be inferred that in any of these cases investigation would prove the expense warranted,—especially that of laying additional tracks. It is, however, my judgment that in most cases additional tracks would be necessary to make the system profitable. Many examples might be given of interurban steam railway systems where investigation might show that it would be profitable to change to electric traction. In concluding the general discussion, and before taking up the detailed examination to follow next month, emphasis must be placed upon the importance of radical changes in present steam-railway methods to make the change to electricity pay. Electric traction in connection with existing tracks and equipment and under existing operative methods will result in heavy loss and ultimate abandonment of the change—possibly even in disaster.

CANAL IRRIGATION IN MODERN MEXICO.

By C. P. MacKie.

THE attention now being paid to scientific irrigation is only another case of history repeating itself. In fact, in the United States and Mexico, irrigation was practised extensively long before the beginning of authentic history. At the time of the Spanish invasion of Mexico, the Indians in those parts of that country where the population was greatest were dependent upon this method of agriculture for a large part of the cereals and cotton which played so important a part in their economy. As the same method had been employed from time immemorial in old Spain, it followed that, on the partition of the soil among the Spanish conquerors, irrigation became almost the basis of their agriculture, and has continued so to be, on a constantly-expanding scale, for the three hundred and fifty years that have elapsed since their final occupation of the Mexican territory.

With the extension of railway lines and the notable impulse given to agricultural enterprise within the last twenty years, Mexican land-owners have improved more and more upon the earlier methods, and have, to an increasing extent, applied the principles of engineering science to the methodical cultivation of the large tracts into which their holdings are usually divided. While these increased facilities are opening up new and extensive regions among the fertile lands of the coasts, the great land-owners of the plateau, where tillage was conducted on antiquated lines, are responding to the same impulse of progress by more scientific employment of their peculiar advantages. The present article describes a typical modern enterprise of this nature,—the largest as yet undertaken in the republic, but probably only the first of a series of similar undertakings to be established there.

The great plain of northern Mexico embraces nearly the whole of the States of Chihuahua and Coahuila, being bounded east and west by the Sierras of the Pacific and Gulf coasts respectively. It consists of two water-sheds,—that of the Rio Grande to the north, and the so-called Desert of the Bolson de Mapimi in the south. It is about 400 miles wide by 600 long, and maintains a general level of about 4,000 feet above the sea, although much broken by local mountain ranges. The Bolson de Mapimi has much the same formation as the basin of the Great Salt Lake. It receives the drainage of all the eastern slopes of the Durango Sierras and the western slopes of the Coahuila ranges, but possesses no outlet. As a consequence, throughout its whole area, the rivers run into broad, shallow lakes, whence the waters are gradu-

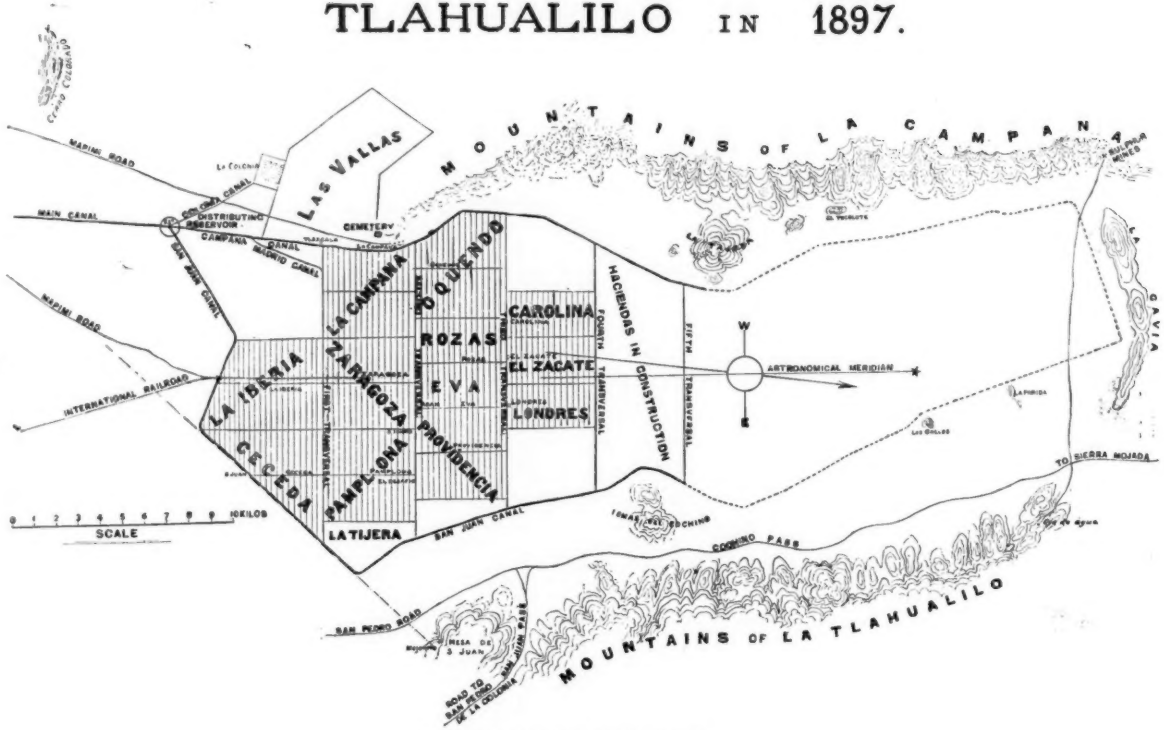
ally lost by evaporation during the dry season. Of these rivers, the largest is the Nazas, which has a course of nearly three hundred miles from its source to where it is dispersed over the shallows, called on modern maps Lake Mayran. Sixty or seventy years ago the Nazas discharged its waters into a series of extensive lagoons, occupying what is now the fertile Laguna district of Durango and Coahuila, still often depicted on the maps as Lake Cayman. About that time a phenomenal and long-continued rain-fall so overcharged the then bed of the Nazas as to cause it to open a new course and leave the Cayman lagoons thirty miles on one side. In the course of years these lagoons were converted into a mesquite wilderness, almost dead level and composed of a deposit of the finest detritus, of unknown depth. The central depression of this lake-bed filled a broad valley running north and south and surrounded by a parallelogram of mountains. The area thus comprised was about two hundred and ten square miles of pure vegetable loam, locally known as the Lake of Tlahualilo. This *cuenca*, or bowl, was the spot chosen about six years ago for the establishment of the great irrigation enterprise now under review.

The problems involved called for courage and high administrative qualities, as well as technical engineering knowledge. It had early developed that the lands left dry by the changed course of the river were of extraordinary fertility, and a half a century ago those tracts immediately adjacent to the river had been taken up and brought under irrigation after the rough methods then practised. The result was that by 1890 about 250,000 acres of this land were under ditch, and the region was producing the greater part of the cotton grown in Mexico, as well as heavy crops of corn and wheat. The Tlahualilo basin was known to be the richest portion of this district, but the thirty miles of sun-baked desert separating it from the present course of the river presented an obstacle to its utilization which proved too formidable for the then cultivators of the Laguna country. In 1889 a project was formulated for carrying a ditch across the intervening desert to the head of the Tlahualilo *cuenca*, and converting the whole of the latter area into a huge hacienda. Don Juan Llamedo, a prominent Spanish capitalist and landed proprietor of Mexico City, was invited to realize this plan, and the unfailing public spirit and far-sighted patriotism of President Diaz aided the enterprise by the concession of the water privileges and rights of domain necessary for its success. Preliminary survey showed that the lowest level of the basin to be irrigated was about one hundred feet below the point on the River Nazas which it was proposed to dam; that the main canal, on account of topographical conditions, would require a development of 39 miles; and that the slope of the lands within the basin was such

DON JOSE FARJAS.

that about 175 square miles out of the 210 composing the basin could be advantageously irrigated. A company was formed to undertake the work, and the organization and execution of the plan of irrigation was entrusted by Señor Llamedo to Don Jose Farjas, an officer of engineers in the Spanish army. An estate of more than 20,000 acres, lying on the River Nazas above all existing dams, and controlling the water-supply, was purchased, and a dam of piles and riprap thrown across the river at a point where it is about 1,500 feet wide at flood. From this dam the line of the main canal was traced to the entrance of the Tlahualilo basin,—a distance, as has been said, of 39 miles. The canal was given a width of 72 feet at the base, a depth of 6½ feet, and a grade of from 18 inches to 3 feet to the mile, except as to one section to be later referred to. It terminated in a distributing tank, at the entrance to the irrigable area, whence it bifurcated, one arm being carried along the western side of the basin and the other along its eastern side. These branches preserved the same average grade; one of them being 15 miles long with a width of 30 feet at the bottom and a depth of 5 feet, and the other being 13 miles long with a width of 36 feet at the bottom and a depth of 6 feet. The area thus enclosed as a beginning was approximately 90 square miles, or about 57,000 acres, and the lines of the side canals were prolonged down each side of the basin until they met at its farther extremity, thus encircling all of the available land. For the time being, however, construction was limited to the distance above referred to. The 90 square miles which were to be first irrigated were laid out in blocks of uniform size, each one containing a Mexican *sitio*,—a conventional area measuring a Spanish league on either side, and embracing about 4,338 English acres. This was accomplished by digging transverse ditches at right angles to the side branches, and running

TLAHUALILO IN 1897.



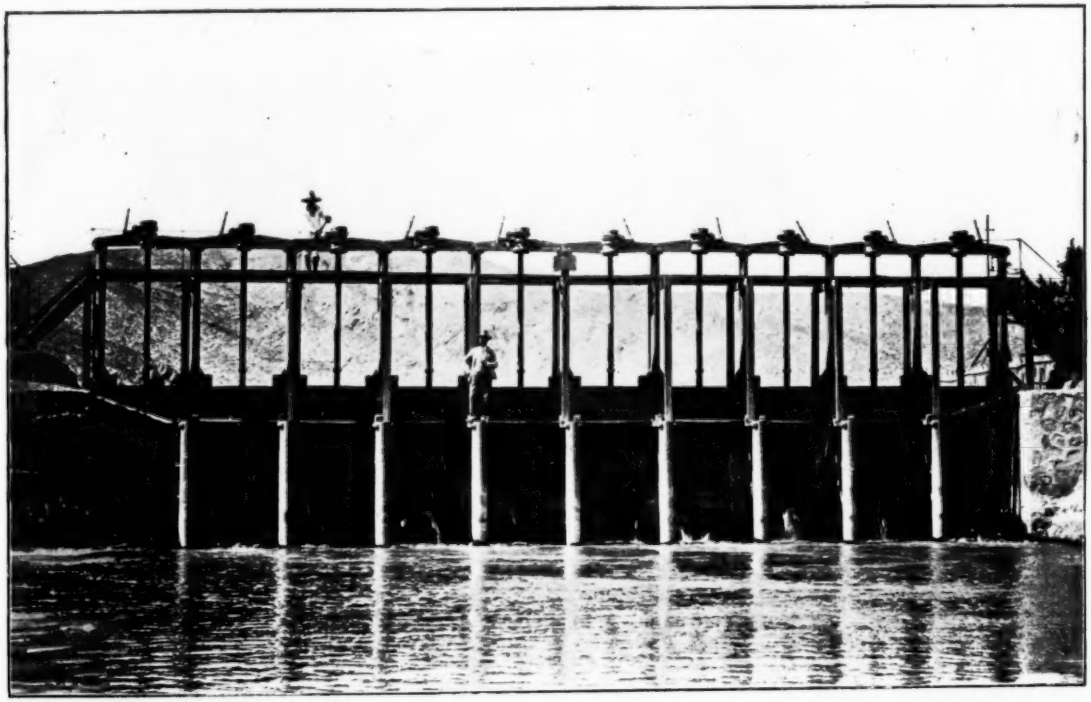
SKETCH MAP OF THE CANAL SYSTEM.

from one to the other. The first of these transverse ditches was a Spanish league (2½ miles) from the distributing tank; the second, the same distance farther on; and so on. Each of them was 25 feet wide at the base and 3½ feet deep. These transverse ditches were, in turn, connected at distances of half a Spanish league by similar ditches at right angles to the "transversals," but parallel with the side branches, having uniform dimensions of 13 feet in width at the bottom and 3 feet in depth. Finally, these parallels were connected, also at right angles, by distributing ditches at intervals of a little more than 800 feet, with dimensions of 6½ feet in width at bottom and 2½ feet in depth. From this description and the accompanying map it will be seen that the system adopted secured absolute uniformity of dimension, both as to ditches and areas of land, thus securing also the incalculable advantage of simplicity and symmetry in the irrigation of the lands and in their subsequent agricultural administration. The unit of cultivation was the *tablas* between the distributing ditches, each of which was 285 yards wide by 2,280 yards long, or about 134 acres. Sixteen of these lay between each pair of parallels and the respective transverse ditches, and two of such blocks, or the area embraced between every second parallel and its corresponding transversals, constituted the *sitio* of 4,338 acres, which was made the unit of administration. The total ditching called for under the above plan was as follows:

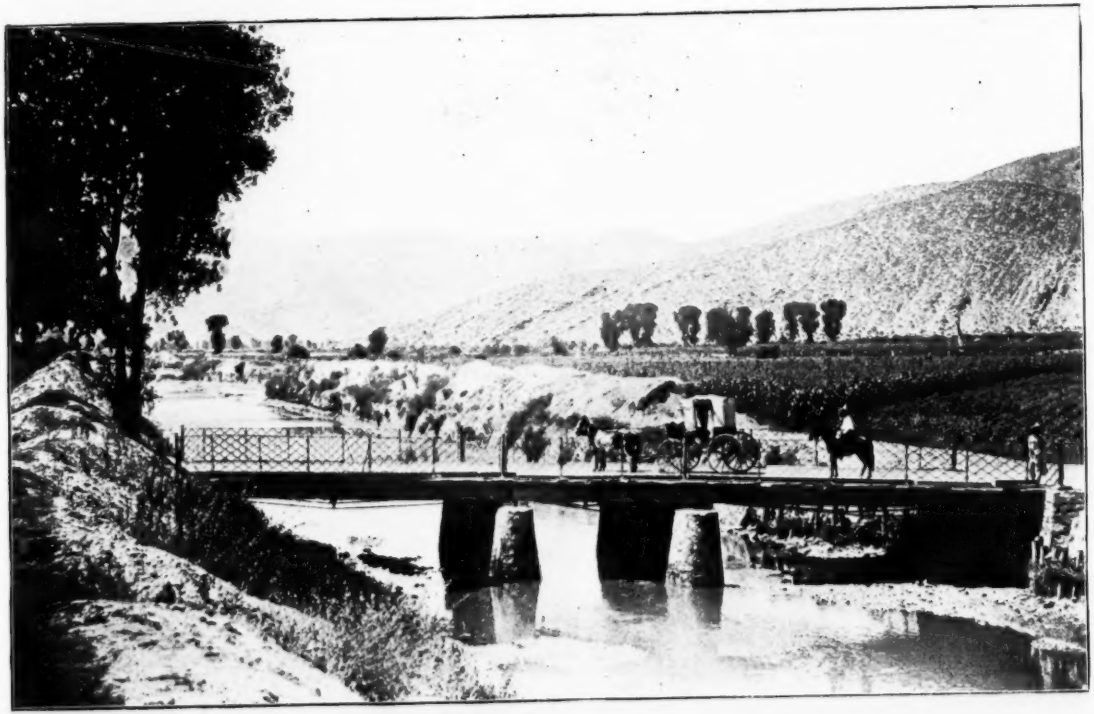
Main canal.....	72-97	feet	wide,	6½	feet	deep,	39 miles
First branch canal.....	33-35	"	" ,	5	"	" ,	15 "
Second " "	36-42	"	" ,	6	"	" ,	13 "
Transverse canals.....	21-23	"	" ,	3½	"	" ,	29 "
Parallel ditches.....	13-16	"	" ,	3	"	" ,	50 "
Distributing ditches.....	6½-9	"	" ,	2½	"	" ,	400 "

The total excavation called for was about 3,700,000 cubic yards for the main canal, and for all the other canals and ditches on this first section about 3,400,000 cubic yards.

The construction of the works was unusually laborious, on account of the difficulty of obtaining water and supplies for men and animals after reaching the limit of convenient haulage from the river. For twenty-five miles of the distance all the water required for the laborers as well as the animals had to be carted, as well as all of the supplies. From 2,000 to 3,000 laborers, Indian peons, were employed on the work, and the time consumed in digging the main canal was a little more than a year. Most of the excavation was done in the peculiar indurated clay, approaching almost the density of soft stone, called by the Mexicans *tepetate*, which, while hard to work with pick and spade, affords a very consistent and permanent bank. Some trouble was ex-



HEAD-GATES OF THE MAIN CANAL.

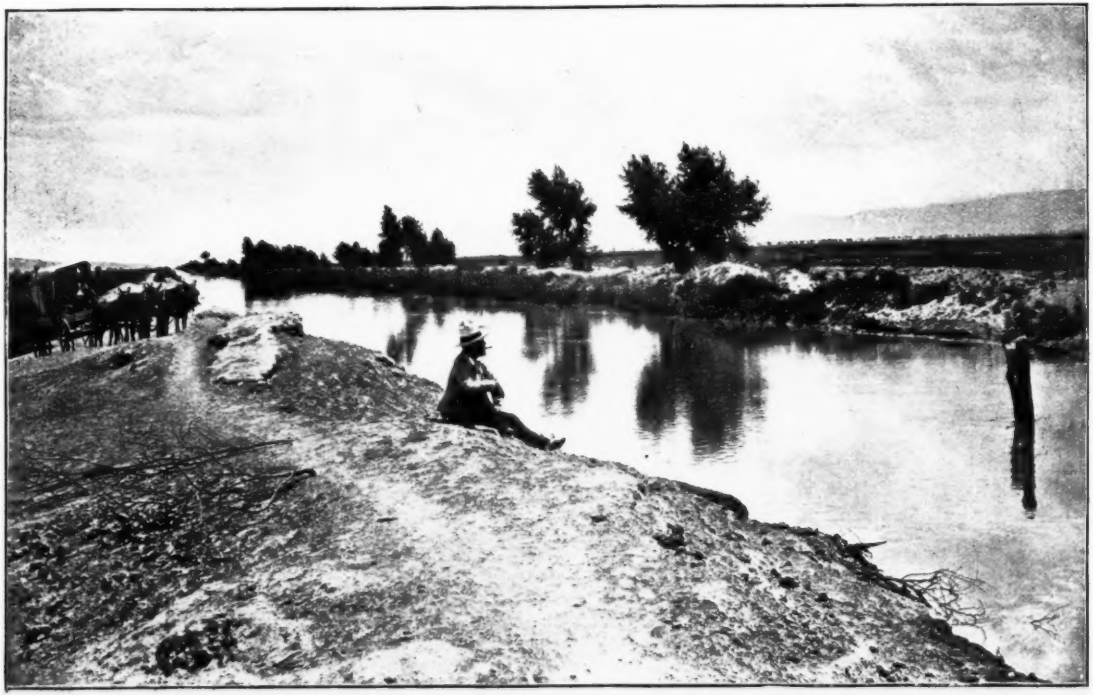


THE MAIN CANAL AT LOW WATER.

perienced from ridges of rock which had to be blasted, and again from beds of drifting sand which had to be secured, but by far the greater part of the work was through *tepetate* and sandy loam. Within the first few miles the line of the main canal traversed three large irrigating ditches, furnishing water for haciendas farther down the river, and these had to be deviated from their former course and carried over the Tlahualilo canal on iron aqueducts. About twenty-five miles from the river the ground dropped off rapidly in the direction the canal was taking, and for three miles it was necessary to increase the grade to eight feet to the mile,—a proceeding which would have been of doubtful prudence but for the durable banks and bottom afforded by the peculiar formation alluded to. About half way down its length the canal cut the line of the Mexican Central Railroad, and here it was necessary to introduce a permanent bridge and take due precautions against washings and over-flow.

The intake of the canal on the river was substantially built of cut masonry laid in Portland cement, with massive wing walls. The gates are ten in number, each 6 feet wide, and, with their frame-work, are of iron. The bottom of the canal for some distance within and without the gates is laid in cement and stone. The sill of the intake is 6 feet below the level of the river dam. The distributing tank at the end of the thirty-ninth mile is built in an equally substantial manner. When this point was reached, work was pushed along the two side branches, and, as fast as they were completed, the transverse canals, parallels, and distributing ditches were opened up between them. As this work progressed, part of the laborers were withdrawn from ditching, and employed in clearing the lands of mesquite and cactus. An ample equipment of the most approved agricultural implements and utensils had been imported in advance from the United States and England, and there was thus no dislocation of energy, some of the peons being shifted from ditching to clearing the land, and then to its ploughing and cultivation, while others were assigned to the work of constructing the many edifices required for the large agricultural operations contemplated.

This preparatory work was so planned as to develop into the permanent administration and operation of the properties without further complications. Each of the *sitios* of 4,338 acres was placed under an administrator, who had his own cashier, accountant, and necessary foremen, with his quota of labor and equipment. He was charged with the work of constructing at a central point on his hacienda a village, containing the administration buildings, magazines, storehouses, stables, corrals, houses for his laborers, and a reservoir of water. The general administration was located on the hacienda of Zaragoza, about



THE MAIN CANAL AT HIGH WATER.

EXTENDING THE DITCHES.

eight miles down the basin from the distributing tank and nearly in the center of the land then being prepared for cultivation. At this point, in addition to the hacienda buildings above enumerated, extensive manufacturing facilities were erected, consisting of a steam cotton gin, an oil mill for handling all the cottonseed oil, a soap factory for utilizing the oil product, a cotton press, and an electric-light plant. There were also built a church, a public school for the children of the company's employees, a general market, a hospital, and other conveniences for the welfare of the population in their isolated position. Throughout the whole property, the main buildings were substantially constructed of adobes and brick, with tiled roofs. A system of wagon roads following the lines of the main canals was laid out to connect all of the villages with the central administration, and telephone communication was established between all of the administrators and the general manager at Zarogoza. During the present season nearly thirty miles of narrow-gage railway, operated by steam, are being laid down to facilitate transportation from the more distant parts of the estate to its industrial center. The track is laid on the dikes of the large canals, as far as possible, thus avoiding the lands overflowed at the time of irrigating. Cotton-wood and eucalyptus trees have also been planted along the larger ditches, for the double purpose of affording shade and breaking the winds on the broad plains.

The method of administration adopted on the completion of the ditches accords with this general plan. The admission and shutting off of the water, the distribution and rotation of the crops, and similar matters of general policy are determined by the general manager at headquarters. The local administrators are expected to keep up the property under their care, oversee the intelligent cultivation of their fields, maintain their ditches, roads, and bridges, and generally care for all the details of the haciendas under their charge. Each administrator is responsible for the accounts of his own hacienda, including the cost of cultivation and the products derived therefrom. He renders a daily statement to the general manager, and receives each day the amount of cash necessary to meet his daily pay-roll, such daily payment in hard cash having been found a sovereign cure for such labor troubles as the peon thus far knows. The company maintains no shops of its own, and allows no monopolies; it grants licenses to any shop-keepers desiring to establish themselves on its property, and applies the sum thus derived towards the maintenance of its public schools. Military discipline is maintained in all of its villages, and prohibitive penalties make the sale and use of intoxicating liquors a costly luxury both for seller and buyer.

The rainfall in the Bolson de Mapimi is confined to a few days of

COTTON FIELDS AFTER THE SPRING IRRIGATION.

COTTON FIELDS AFTER THE FALL IRRIGATION.

heavy showers about the beginning of June and the beginning of December. But up in the mountains of Durango, where the Nazas takes its rise, the rainfall at the same season is very heavy and protracted, resulting in high water in the river, which lasts for several weeks at a time. It is during these freshets that the cultivated lands in the Nazas district are irrigated. For the rest of the year they receive no water, except from occasional brief showers. In the Tlahualilo basin, a week or ten days of irrigation is all that is needed in the course of a year, the water soaking easily and quickly through the almost impalpable silt, and the hot sun forming a protecting crust which checks evaporation and retains the moisture in the sub-soil for a surprisingly long time. In fact, owing to their long roots, the cot-

A PRODUCT OF IRRIGATION.

ton plants strictly require irrigation only once every other year, but corn and wheat, of course, must receive it at each planting.

The distribution of the waters is regulated by government schedule, each property on the river being allotted its proportion of water, according to priority of settlement. Each canal on the river is permitted to take as many irrigations as it desires during the season of high waters, but in strict rotation. That is, after a property has taken one quota, it cannot repeat the process until all the others have taken theirs, when its second quota is available. Where another property, as often happens, does not care to use all the water to which it is entitled, its further allotments may be used by its neighbors.

For the Tlahualilo canal the maximum delivery at the distributing

A FARM SUPERINTENDENT AND HIS STAFF.

MEXICAN INDIAN LABORERS AND AMERICAN MACHINERY.

tank at the entrance of the basin would be 1,440 cubic feet per second, with an irrigating capacity of about 115,000 acres of land, calculating the duty to be 80 acres per cubic foot. This is allowing a reduction from the amount entering the head-gates at the dam of about twenty per cent. for evaporation, seepage, and absorption, which is found to be a fair allowance in the region traversed by the canal. Actually, for the amount of land at present under ditch on the haciendas,—say, 57,000 acres,—the water service is about 650 cubic feet per second. About eighteen hours elapse from the time the water enters the head-gates before the ditches begin to fill on the haciendas. The water is served to each of the *sitios* in order, the ditches of each *sitio* being shut off by their respective sluice-gates when full. For the purpose of thorough irrigation, the *tablas* of 134 acres each are divided by low internal banks into convenient squares, and the water is admitted into each of these squares from the distributing ditches, until it stands about two inches deep over the entire area. It is then shut off, until the time for another irrigation. By this process every plant, from the first ditches on the haciendas to the last, receives its modicum of water, without danger of excess. The waters, on leaving the river, are heavily charged with sediment largely volcanic in its origin, and this is deposited on the lands at each flooding, in the shape of extremely fine mud.

Owing to the distance from the nearest coal mines, the question of fuel is an important one, as there are at present more than three-hundred h. p. in constant use, and the amount is steadily increasing. The main supply is from the mesquite brush, which is cleared from the new lands as the work of ditching and preparation advances. The hulls of the cotton seed also make a hot, but quick, fuel for some of the larger stationary engines. The wheat straw and cotton bushes are utilized for brick burning and for the domestic purposes of the laboring population. The engines and fixed machinery, as well as all the agricultural machines, are operated by native labor, the peons having been found quick and efficient in acquiring a certain degree of mechanical knowledge. During the period of greatest activity, when the cotton crop is coming in, the gins, presses, and oil mills are kept running day and night, the company maintaining a considerable electric-light plant for this purpose. All the products of the haciendas are shipped direct from the station at Zaragoza to their destinations. The cotton, wheat, corn, and soap are all marketed in the republic; the oil cake is shipped to the United States. Most of the machinery and implements employed are of American origin, and their aggregate is very large, there being at present more than seven thousand American plows of different types in use on the estates.

The recent construction of a branch line from the Mexican International Railroad at Matamoros across the plains to the center of the Tlahualilo property, by supplying adequate transportation, has made it possible to extend cultivation to the remainder of the basin. The side canals are being prolonged, and, pursuing the system heretofore adopted, four new *sitios* of 4,338 acres each are being prepared for their first irrigation later in the year, and for equipment with the standard type of villages and all necessary appliances. It is purposed to continue this work as rapidly as the work of ditching and clearing will permit, and it is estimated that by the end of 1899 the entire area of 175 square miles will be under ditch and producing.

Six years of experience with this property demonstrates the fact that irrigation, when applied to fertile land under a carefully-planned and thoroughly-executed system, where the water-supply is owned by the user, puts agriculture among the least dubious of industries The plan adopted by the Tlahualilo Company is especially worthy of attention, because of the notable unity of plan pursued from the inception of the enterprise to its fullest development, and of its resultant economies. Too often enterprises formed for the furnishing of water for irrigation purposes fail for want of a market for their water; and others, formed for the utilization of such waters, fail because of excessive cost, or of friction with the controllers of the water supply. The remedy would seem to be an enlargement of the scope of such enterprises, so as to include both the control of the water-supply and its utilization. Under thorough systematization, proper control and direction can be exercised economically and efficiently, from the admission of the water at the first head-gates to the shipment of the marketable products to their final destinations. Methodical control is the basis of successful operation in railroad and other industrial enterprises on a large scale, and the example we have given proves that like causes will produce like effects in agricultural operations as well.

AMERICAN AND BRITISH BLAST-FURNACE PRACTICE.

By J. Stephen Jeans.

COMPARATIVE LABOR COSTS IN THE UNITED STATES AND EUROPE.

WHENEVER pig-iron makers have assembled for the purpose of comparing experiences as to the cost of iron-production in different districts or countries, it has been the custom to appeal to the average volume of output as the standard of efficiency. In only a few examples that I know of has the output of pig iron relatively to the number of hands employed been appealed to. There is, no doubt, good reason for this reticence as to labor costs. Those whose labor costs are high are hardly likely to disclose a fact that would probably be quoted against them, perhaps to their discredit. Those, on the other hand, whose labor costs are low are just as little likely to make disclosures leading to inquiries and to action calculated to deprive them of comparative advantages, due to a low district rate of wages, or to an exceptionally efficient system of administration.

In determining the comparative efficiency of blast-furnace working from the labor point of view, there are three standards that we may appeal to. The first of these, dealt with in a previous article, is the actual output of the furnace; the second is the output relatively to the number of hands employed; and the third is the output as measured in terms of labor costs per ton of pig.

It is obvious that the first of these determinants is not necessarily an effective measure of comparative economy. The fact that a blast furnace may be producing four hundred or five hundred tons of pig every twenty-four hours does not alone establish a criterion of efficient working, because that output may be obtained at so high a labor cost as to make it relatively more expensive than a smaller output produced under different conditions. There is, to be sure, a presumption that a large output means economy of labor, but not a certainty.

It is interesting, and to a certain extent profitable, to ascertain, as far as possible, how the different iron-producing countries compare with each other from the point of view of labor-efficiency at blast furnaces. But we can hardly take up any economic subject in reference to which there is a greater liability to error. Time and again it has been my duty to point out that a comparison of the output of minerals in different districts or in different countries is valueless as a test of labor-efficiency, unless all the differentiating conditions are understood and taken into consideration,—regularity of working, depth, thick-

ness, and character of seams, and many other elements affecting the ultimate cost. It is much the same in reference to the pig-iron industry. The size and character of the furnace, the physical structure of the ores and fuel, the comparative poverty or richness of the mineral, the grade of iron made, the pressure and temperature of the blast, and other manifest influences have all to be taken into account in the estimation of the comparative efficiency of different works or districts.

There are two methods of approaching this subject: first, that of dealing with different countries, as such; second, that of considering the circumstances of individual works. We cannot, except to a very limited extent, adopt the latter system, partly because the owners of individual works are likely to entertain a natural reluctance to seeing themselves used for such a purpose, no matter whether their results are better or worse than the average, and partly because the results of individual works cannot, as a rule, be accepted as typical of a whole district or country. The greater includes the less; and, if we deal with each country as such, we shall both give a greater breadth to our subject, and avoid the liability to errors of generalization that would be incurred under any less comprehensive method of treatment.

On the threshold of our inquiry we are met by a formidable and insuperable difficulty. All countries now collect and publish statistics of the production of pig iron, but all countries do not collect and publish statistics of the numbers employed in particular industries; and, in the absence of data on both points, we cannot make a just comparison. Fortunately, we have complete labor statistics for Germany, Belgium, Sweden, Austria, Luxembourg, and Russia; but we have no similar returns for the United States, Great Britain, or France. Up to a certain point, therefore, we must confine our comparison to the published official returns of the six countries first named. The census returns for the United States are doubtful, and the available returns of individual districts or works in the United Kingdom scarcely go far enough to enable any general estimation of results to be arrived at that would be effective for purposes of international comparison.

I.—Belgium.—In this active little country the records of the manufacture of pig iron have been officially collected and published for upwards of half a century, so that we are able to go back to an earlier date here than in any other country. In 1845 the total output of pig iron in Belgium by 2,331 workmen was 134,563 tons, or an annual average of only 58 tons per workman. In 1850 this average had not improved, but in 1855, mainly owing to the substitution of coke for charcoal furnaces, it had risen to 66 tons, and in 1860 to 80 tons, while in 1865 the average had attained 97 tons, or nearly twice the figure recorded for 1845. Even so, however, the Belgian pig-iron in-

dustry was only on the threshold of its advances, from the labor point of view. Old plants were got rid of, and new plants were substituted rapidly, during the next twenty years or so; hence, in 1884, the average output per worker rose to 207 tons, or more than twice the average of 1865. At this date Belgium was ahead of every other iron-making country in point of economical production of pig iron at the furnace, although not necessarily producing iron more cheaply than any other country. The nearest approach to the Belgian standard between 1883 and 1885 was that made by Luxembourg, which produced 194 to 200 tons per worker, and Luxembourg was followed at some distance by Germany, with an average of 145 to 150 tons per worker. As for the United States, we can say only that in 1880 the total number of hands employed at the blast furnaces, according to the census returns, was 41,875, which, divided into the output of pig iron in that year, gives an average annual output of only 80 tons per worker, or 61 per cent. less than the Belgian average. American iron works at that time had their records still to make; but, if late in starting, they have certainly gone ahead since, especially during the last ten years.

This early advance made by Belgium in blast-furnace practice has perhaps hardly been recognized as it deserves to be. It was no doubt affected to a certain extent by the fact that the indigenous minerals of the country had become scarce and dear, and iron smelters were forced to seek for supplies elsewhere. Between 1870 and 1875 Belgium imported larger quantities of iron ore than any other iron-making country in Europe, and, although these imports included a considerable quantity of the lean minette ores of Luxembourg, they also embraced so large a proportion of the richer ores of Spain and other countries as to facilitate a larger output per furnace and per worker. In the interval since 1885, the blast-furnace practice of Belgium has further improved, although not to the same extent as in the previous twenty years. The average annual output of pig iron per worker over the last two or three years has varied from 270 to 280 tons, which compares favorably with that of other European countries, except the United Kingdom, where, as we shall see later, the average rises to a considerably higher figure.

II.—GERMANY.—It is less than a quarter of a century since Germany was the most backward metallurgical country in Europe, from an iron- and steel-making point of view, and in the interval the relative progress made by German smelters has been only slightly behind that achieved by the United States. In 1872 the average annual output per workman employed at the blast furnaces of Germany was only 76 tons less than one-fourth of the estimated average of Great Britain at the present day. But from this low point steady progress was made,

year by year, until in 1880 the average rose to 129 tons, and in 1890 to 186 tons. Since 1890, short as the interval has been, considerable further progress has been made, the average having been 205 tons in 1893, and 220 tons in 1895. Germany still appears to be a good deal behind either Belgium or Great Britain from the point of view of labor efficiency. This, no doubt, is mainly a function of the generally lower grade of the ores used in German blast furnaces. Of the total output of pig in the German empire, amounting now to over six million tons a year, not more than about half-a-million tons are made from ores that average more than 42 per cent. in the blast furnace, whereas in Great Britain about 3,500,000 tons of pig are now made from ores that will average 52 per cent. to 54 per cent., which obviously aids Great Britain in such a comparison. There are, besides, many parts of Germany where the blast furnaces are still behindhand, although there are other cases, as we shall shortly see, where they are well to the front.

Nearly two years ago, as the secretary to the British Iron Trade association, I was called upon to take a prominent part in organizing a delegation of employers and workmen for the purpose of inquiring into the economic conditions of the iron industry of continental Europe. As secretary also of that delegation, it was my business to pay visits to a number of the leading works in both Belgium and Germany for the purpose of ascertaining the differences between British and continental methods of working. Some of the workmen who composed that delegation attached much importance to the differences in the numbers of hands employed at furnaces, rolling mills, or steel works at the several establishments visited, and insisted that the numbers at work relatively to a given output were much greater than at similar works in England. In some cases, no doubt, this may be the fact; but at one of the works in Germany, which may be looked upon as typical of several large establishments in Westphalia, we found that twenty-seven men were employed per shift at each furnace making basic iron; and, as the average output of the furnaces was about 750 tons per week, it follows that the average annual product per workman was 720 tons, which is a very different showing from the average recorded for the empire as a whole. In this case, of course, we counted only the men employed at and about the furnaces. It may be interesting to show how these figures were made up, as furnace-owners may thereby be enabled to make a comparison with the similar data available for American and British works.

The *personnel* per furnace per shift was thus composed: three smelters; one tapper; two chargers; four coke, etc., fillers; four ore fillers; four transport men; one lift man; one weigh man; three men

at switches, etc.; one stoneman; one limestone breaker; one ore breaker; one locomotive man. Probably it may be argued that this does not include the sum of furnace labor; it may be argued that the men who are at the blast engines, at the boilers (engaged in repairs), and at the pig beds, and even clerical labor should be included; but at any rate the enumeration gives a basis from which to work in comparing the similar records of other localities.

III.—SWEDEN, ETC.—The conditions under which the iron industry of Sweden is carried on possess little more than a merely academic interest, so far as labor is concerned, for the iron-making world generally. All the pig produced is charcoal; the furnaces are small and worked irregularly; the ore, as a rule, is exceptionally rich; the motive power is largely furnished by water; and the hands do not work exclusively at the furnaces, but alternate metallurgical with agricultural pursuits. In some of these matters, changes have occurred within recent years which tend to place the Swedish iron industry on a somewhat different level from that which it formerly occupied. Thus, for example, if we go back to 1866, we find that the average number of working days per furnace per annum was only 150; in 1876 it had risen to 190; and in 1895 it was 252. The average annual production of pig per man employed was only 64 tons in 1866, which advanced to 77½ tons in 1876, and has in late years increased to more than 100 tons, the average annual output per furnace having concurrently increased from 1,045 to 3,170 tons. Sweden, indeed, can hardly be looked upon as having to meet competition in the sense in which other European countries have to face it. Her remarkably pure ores, her unlimited supplies of charcoal, and the characteristics of her industry generally, mark it as a thing apart. The same observations apply, *mutatis mutandis*, to the still less important, but yet more isolated, iron industry of Finland, where the average annual output of per man working at the furnaces is only from 65 to 75 tons, the total annual output being less than that of one of the smallest furnaces in the United States. Nor does it appear to be expedient to make extended reference to either Austrian or Russian blast-furnace practice, as the isolation and special conditions in both countries rule them out of any international comparison founded on modern competitive conditions.

IV.—THE UNITED STATES.—In no country has economy of labor within late years been carried farther or become more effective in relation to the pig-iron industry than in the United States. The question has often been debated between British and American pig-iron makers whether labor is more economical in the one country than in the other,—that is, as measured in terms of annual product per employee. The blast-furnace practice of Great Britain, until lately at any rate,

claimed to be ahead of that of any other country from this point of view, and Sir Lowthian Bell and others have denied that American practice was more satisfactory than that of Great Britain, owing to the larger number of hands that were generally understood to be employed. In this respect, however, considerable changes have again taken place during recent years, as we shall see later.

That the cost of labor employed at the furnace in the production of a ton of pig-iron was formerly excessive in the United States can hardly be questioned. The former secretary to the Eastern Ironmasters' Association has put on record the labor costs at the furnace for a series of years preceding 1880, showing that in some years it was as much as $5, and that between 1864 and 1877 it was never less than $2.50. Sir Lowthian Bell has given details of furnace practice which he obtained at works visited between 1871 and 1875, showing that the labor cost per ton of pig at the furnace, during that period, was between $2.50 and $2.75. At the blast furnaces in the south the average wages per ton in 1880 exceeded $6. These high figures are now a thing of the past. In the best American furnace practice of to-day, the average labor cost at the furnace per ton of pig does not exceed a dollar, and in some cases is materially less. So far as my information goes, the labor cost at the new furnaces at Duquesne will not much exceed half-a-dollar per ton of output, and in the south in 1890 the average wages paid at the furnaces was only $1.05 per ton.

In 1895 I paid a visit to the United States and made inquiries into the conditions of labor at some of the principal blast-furnace plants, a portion of the results of which have been published in the *Iron and Coal Trades Review*. One of the points upon which I sought information was that which has been discussed in this paper. I learned that at some of the best plants the number of hands employed to produce 250 tons of pig iron per day was 126, so that the daily unit of product was about two tons of pig per man, including all artisan labor. This is a high average. It may be taken to represent the best American practice on anything approaching a large scale. But it is not equal to the average of some British works within my knowledge, where the average annual product per employee exceeds 800 tons, using bessemer ores in both cases. In districts where leaner ores are employed the output is naturally less. I have before me particulars of one of the largest and best-equipped plants in the Midlands, using clay ores, averaging not more than 40 per cent. of iron, where the average daily output per employee is 1.6 tons of pig, or nearly 600 tons per annum. I greatly doubt whether better results are obtained at any American or European (continental) works using similarly low-grade ores.

All American and most continental ironmakers are acquainted with

the very elaborate details which were collected and published on this subject by Mr. Carroll D. Wright as the United States commissioner for labor, in 1890. I have examined Mr. Wright's figures, perhaps as carefully as any one, and I have come to the conclusion that, although for most practical purposes they are of comparatively little value,—chiefly because of the absence of information as to geographical and other governing conditions, without which no fair comparison is possible—yet, in one respect they are not far from the truth, *viz.*, as to the average cost of labor at furnaces making bessemer iron at that time.

Like other investigators in the same economic field, Mr. Wright has found the extreme difficulty that always exists in procuring figures relevant and parallel to each other, but, if we take his figures for the United States, Great Britain, and an iron-making country on the continent,—presumably Westphalia,—and assign to the latter the same items for clerical labor and taxes as have been ascertained for British furnaces, we have the following result:

	Cost per ton of pig iron.		
	United States.	*Great Britain.*	*Continent of Europe.*
Labor	$1.386	$0.669	$0.517
Officials and clerks	0.158	0.056	0.056
Supplies and repairs	0.533	0.406	0.406
Taxes	0.039	0.020	0.020

I feel sure that the British figures are fairly typical, but the continental figures represent an exceptionally favorable condition of affairs, and it is probable that of the total costs at the furnace in this latter case, amounting to $0.999, something more should be assigned to labor, and something less to the other three items; but, even so, the margin of possible error can be only slight. The figures ascertained by the commissioner of labor show that in the United States, in 1890, the labor cost at the furnace of a ton of pig iron was twice what it was in Europe. Now, this difference is so serious that it suggests either a very much higher rate of wages in the United States, or a lower labor efficiency. Compared with continental Europe, I have no doubt that the difference against American labor costs is wholly due to the higher rate of wages paid, seeing that the official average recorded for Belgian blast-furnace labor is not much more than two shillings per day. But this remark is by no means equally applicable to British labor. Indeed, I am in a position to assert with confidence that at the present time, and for at least two years past, the difference in the rate of wages paid at blast furnaces in Great Britain and the United States is not so much as is commonly supposed. In 1895 I obtained from two typical works—the one American and the other

English—the following details of the wages then current at the blast furnaces, in two leading iron-making districts, and I think the figures of to-day do not greatly differ from them.

	United States.	*United Kingdom.*
	s. d.	*s. d.*
Top fillers	6. 4½	4.11
Bottom fillers	5. 7	4. 7
Cagers	5.11½	4.11
Ore shovellers	5. 4½	4. 0
Lime breakers	4.11	4. 0

Generally speaking, these figures appear to show, so far as they go, that the wages cost of labor at furnaces in the United States is less than 30 per cent. in excess of that of Great Britain, and, although this figure would be more or less modified by returns collected over a larger area, I do not think that the general result would be greatly affected. But, as we have to account for a difference of 100 per cent. against the United States (dealing still with Mr. Wright's returns), it is manifest that something still remains to be explained.

I have come to the conclusion that in the United States artisan labor costs considerably more per ton of output than in Europe. The wages cost of such labor, to begin with, is much higher. In the two typical cases named, the daily wages paid in 1895 were as follows:

	Average daily rate of wages.	
	United States.	*United Kingdom.*
	s. d.	*s. d.*
Blacksmiths	9. 4	4.7
Machinists	10. 1	5.4
Carpenters	7. 3	4.6
Bricklayers	7.11	4.8

Here we have a difference of nearly 80 per cent. against the United States, for the four items tabulated. But it is also probable that, owing to the harder driving common in the United States, and the much more rapid wear and tear inevitable to the greater rush, the artisan element in the cost of production is much greater in American than in English practice. 'Tis the pace that kills; and neither men or mice are exempt from this rule.

A notable improvement has taken place in the economy of blast-furnace working in all countries since 1890, and I do not wish to be understood as implying that Mr. Carroll D. Wright's figures of 1890 are applicable to the present time. There is no general standard whereby we are able to judge of the extent of that improvement, but in some cases it has been very considerable indeed. In the United Kingdom, for example, I believe that no blast furnaces in 1890 pro-

duced more than 900 tons per week, and perhaps not more than a dozen had reached that figure. To-day we have blast furnaces producing 1,400 to 1,500 tons weekly. I am not aware of any blast furnaces in 1890 that produced pig iron at a lower labor cost at the furnace than three shillings per ton. I know to-day of cases where the labor cost is less than two shillings per ton. It is probable that in the United States even greater progress has taken place. In the interval, at any rate, we have seen the price of southern pig iron brought down from $12 to little more than $6 per ton, and bessemer pig has fallen from about $18 to $12 per ton at the furnaces.

Looking to the future, there is every reason to suppose that a large measure of progress remains to be achieved. What is to be the normal standard of attainment in the future? Is it to be that reached by the new Carnegie furnaces at Duquesne in the United States, that of the new Dowlais furnaces at Cardiff in Great Britain, and that of the Phœnix furnaces at Rubrost in Germany? If so, in all three countries the next decade must witness a large reconstruction of blast-furnace plants. The average output of the furnaces that have been in operation in these three countries for the last three years, as nearly as can be ascertained, has been as follows:

United States.....	44,000	tons per annum.
Great Britain.....	23,250	" " "
Germany.....	24,500	" " "

But, if all the furnaces in operation were to work up to the figures reached by the three establishments named, the average output per furnace would be:

For the United States.....	182,000	tons per annum.
" Great Britain.....	78,000	" " "
" Germany..... ...	98,600	" " "

Hence we reach the remarkable conclusion that, assuming parallel conditions, we should have an annual output of nine million tons of pig iron in the United States with only 50 furnaces, where 185 are now employed; an output of eight million tons in Great Britain with 102 furnaces, where 350 are now employed; and an output of six million tons in Germany with about 60 furnaces, where 205 are now operated. These figures are not, of course, likely to be realized in actual practice, and are not put forward with that idea, but rather as an indication of the improvement and economy that must be achieved before the blast-furnace practice of to-day can be coördinated with that proved to be possible under the most favorable conditions. This latter qualification is essential, because manifestly so large yields as those of Duquesne, Dowlais, and Rubrost are possible only when rich ores, good coke, and other favorable elements are at command.

EPOCH-MAKING EVENTS IN ELECTRICITY.

By G. H. Stockbridge.

II.—OERSTED.—MAGNETISM AND MOTION FROM THE ELECTRIC CURRENT.

I MAGINE an ancient Greek philosopher, impregnated with the mythologic teaching that made the west wind a living person and peopled the forests with fauns and nymphs and satyrs,—imagine such a man set down among us of this generation, and acquiring a profound knowledge of our modern science and of the useful arts that have been born of it. It is not unlikely that, in the first glow of his wonder at our present comforts and conveniences and our exacter theories of nature, he would be filled with a great regret over the long past, and would exclaim: "Alas! how false it all was! There was no good in it!" On the other hand, for four hundred years the world of scholarship and intelligence has been saying: "How beautiful it was!", and latterly, since science itself has grown wise enough to see it: "How true!" The Greek would be at fault in making what was really beautiful seem less an expression of the truth; it is we who are at fault, if by any undue insistence upon short views in science, or any exclusive or undue glorification of mere formula and fact, we have made the true seem less beautiful. Nothing is more wonderful and inspiring than the achievements of science; few things are duller than the discussions of detached, unrelated fact, which often make up the proceedings of the typical scientific society.

The intense specialization of science is at once the secret of its progress and its danger. The pursuit of small things is apt to make us forget that science has any broad horizons, or any looming seas, or any spring seasons of song and sunshine and dream and prophecy. The thing insisted upon here is that the specific, disconnected facts occupy at present too great a share of scientific attention. They are a part of science, but not the whole of it. It is an honorable distinction to have said something new and true about the Greek genitive, or to have taught rightly that the name of the most virile of the Latin comic poets was Titus Maccius Plautus, and not Titus Accius Plautus. But it would be a pity to overlook the fact that philology has also even greater things to offer; that one may learn from the comparative study of language some of the shyest secrets of mind,—how the languid climate and tropical luxuriance of the orient softened and yet illumined its mode of speech, and how the expression of the stolid north was made sturdier and more uncouth by the hard conditions of existence on the banks of the frozen streams or among the perilous

mountains. Is the Greek telling of the story of man and nature a particle more enchanting in the end than the tale of the latest science when vivified by the imagination, without which all science is futile and fatuous? I fancy that what is lacking to us is the Greek mind, the Greek insight. If it should happen to Mr. Kipling to have directed the poets of our day to dealing, as he himself has lately done, with the most significant realities of the century,—for such the doings of science and invention assuredly are,—he will be certain of an immortality quite independent of his own great contributions to English literature. The Greeks could turn the yellow fruit of the orange tree into apples of gold, but they could not have told why the ripened apple falls to the ground. In the youth of the world, they were, in the main, sensuous and observing, like all youth, but they did not inquire very deeply. After the world had grown old, the falling apple. the swinging lamp, and the revolving sun wrought a profounder inquisitiveness. But all that marked the presence of a new spirit in the world. The modern scientific period had begun.

Remote as all this may seem, it is worth while to note that Greek mythology and modern science have this in common, that they are impressed more immediately and strongly by the phenomena of force or power. The Greeks personified or deified them ; science gives them the precedence of interest and attention. It was not for nothing that the pioneers of modern science, those who ushered in the era of weighing and measuring, the Galileos, the Newtons, and the Keplers, were first led to study the laws of objects in real or apparent motion. Motion stands plainly for power ; if it be a newly-observed motion, it may point to a new source of energy, a prime mover ; or it may indicate a novel translator of energy, a new secondary motor, which always finds a place of importance in the arts. Whether in the youth or the age of the world, humanity displays its kinship with the forces of nature, the sources of power or energy. And one of the most obvious manifestations of power is motion. The device that quiets the child chains no less the attention of man. In a word, the whole world is enraptured of dynamics, of power made manifest.

Volta's apparatus, of which we spoke last month, revealed itself as a new source of electrical energy. The discovery which forms the subject of the present paper arrested attention by reason of the fact that it disclosed a new means for translating the energy of Volta's pile into motion. No matter whether or not the direct applications of voltaic electricity, as in electrolysis, or otherwise, had exhausted themselves ; here was presented a new promise of applicability, which at once became of the highest significance. How well the promise has been fulfilled is told by all the most striking things in recent elec-

trical development. The electro-magnet, which may be looked upon as a natural evolution from Oersted's discovery, was just what was needed to give Volta's "crown of cups" a lever and a fulcrum. Through the combination of the two have come the telegraph and annunciator and alarm systems, and they play an important part in the operation of the telephone, while each, combined with other devices, contributes its part to the success of many useful systems and appliances. Take the electro-magnet alone; this appears as the controlling organ in the dynamo, the electric motor, the ore separator, and the arc lamp, as well as in the appliances already cited.

But we are now concerned with Oersted's discovery itself, its first publication, its laws, and its later development, independent of its relations to other contrivances or its special utilization in the arts.

Hans Christian Oersted, Knight of the Dannebrogian Order, professor of physics in the University of Copenhagen, and secretary to the Copenhagen Royal Society of Sciences, published on July 21, 1820, a brief Latin treatise having the title: "Experimenta circa effectum conflictus electrici in acum magneticam." In that treatise he tells of some experiments which he and his friend Esmarch, the king's minister of justice (who assisted him by invitation), conducted in the presence of a number of learned men. There was "that distinguished man, Wleugel, Knight of the Danish Order, and president of our pilot board"; and Hauch, "that most excellent man, whom the king has decorated with the highest honors"; "that most acute man, Reinhart, professor of natural history; Jacobsen, professor of medicine, a man most skilful in conducting experiments; and the most experienced chemist, Zeise, Ph. D." In the presence of these distinguished men, Oersted, assisted by Esmarch, repeated a series of experiments which the former had performed before his classes the preceding winter. Beyond the fact that Oersted desired to repeat his experiments with improved galvanic apparatus, fitted up by Esmarch and himself, he appears to have been influenced by the wish to put the integrity of his experiments and of his personal claims respecting them beyond question by summoning as witnesses men of the greatest intelligence and honesty of character. He says, it is true, that his earlier experiments "were conducted with somewhat defective apparatus, and so the phenomena which were produced did not seem clear enough for the importance of the subject"; but it is manifest that he anticipated success with the new battery, and that he wished to substantiate the facts in the presence of unimpeachable witnesses.

Having described the exact character of his galvanic apparatus, Oersted proceeds to set forth a number of experiments as follows:

"Let the opposite poles of the galvanic apparatus be joined by a

metallic wire, which, for brevity, we will call the joining conductor, or joining wire. To the effect, however, which takes place in this conductor and the surrounding space, we will give the name electric conflict.

"Let the rectilinear part of this wire be placed in a horizontal position over a properly-suspended magnetic needle, and parallel to it. If necessary, the joining wire can be so bent that a suitable portion of it may assume the position necessary for the experiment. These things being thus arranged, the magnetic needle will be moved, and, indeed, under that part of the joining wire which receives electricity most immediately from the negative end of the galvanic apparatus, will decline toward the west.

"If the distance of the joining wire from the magnetic needle does not exceed ¾ of an inch, the declination of the needle makes an angle of about 45°. If the distance is increased, the angles decrease proportionately. The declination varies, however, according to the efficiency of the apparatus.

"The joining wire can shift its place either eastward or westward, provided it maintains a position parallel to the needle, without any other change of effect than as respects magnitude; and thus the effect can by no means be attributed to attraction, for the same pole of the magnetic needle which approaches the joining wire while it is placed at the east side of it ought to recede therefrom when it occupies a position at the west side of it, if these declinations depended on attractions or repulsions.

"The joining conductor may consist of several metallic wires or bands connected together. The kind of metal does not alter the effects, except, perhaps, as regards quantity. We have employed with equal success wires of platinum, gold, silver, copper, iron, bands of lead and tin, a mass of mercury. A conductor is not wholly without effect when water interrupts, unless the interruption embraces a space of several inches in length.

"The effects of the joining wire on the magnetic needle pass through glass, metal, wood, water, resin, earthenware, and stones; for, if a plate of glass, metal, or wood be interposed, the effects are not destroyed, nor do they disappear if plates of glass, metal, and wood be simultaneously interposed; indeed, they seem to be scarcely lessened. The result is the same if there is interposed a disk of amber, a plate of porphyry, or even an earthenware vessel, filled with water. Our experiments have also shown that the effects already mentioned are not changed if the magnetic needle is shut up in a copper box filled with water. It is unnecessary to state that the passing of the effects through all these substances has never before been observed in elec-

tricity and magnetism. The effects, therefore, which take place in electric conflict are as different as possible from the effects of this or that electric force."

Other experiments are described, giving the results when the joining wire is moved to various positions, or is bent back upon itself, and the outcome is stated of experiments with certain substitutes for the magnetic needle. Oersted finds, for example, that the effects are inverted when the joining conductor is moved from a position above the magnetic needle to a position below it. He learns, too, that "a needle of copper, suspended like a magnetic needle, is not moved by the effect of the joining wire. Also needles of glass," he adds, "or of so-called gum-lac, subjected to similar experiments, remain at rest."

From all this Oersted adduces, as he says, "some consideration in explanation of these phenomena. Among them are the following:

"Electric conflict can only act upon magnetic particles of matter. All non-magnetic bodies seem to be penetrable by electric conflict; but magnetic bodies, or, rather, their magnetic particles, seem to resist the passage of this conflict, whence it is that they can be moved by the impulse of contending forces.

"That electric conflict is not inclosed in the conductor, but, as we have already said, is at the same time dispersed in the surrounding space, and that somewhat widely, is clear enough from the observations already set forth.

"In like manner, it is allowable to gather from what has been observed that this conflict performs gyrations."

Oersted's treatise became known to the scientific world through being sent "to all of the most renowned natural philosophers and scientific societies." Pursuing the hint afforded by Oersted's experiments, Arago soon discovered that a copper wire connecting the poles of a Voltaic cell would attract iron filings. He also discovered that he could communicate permanent magnetism to steel needles laid at right angles to the copper wire; and, following a suggestion of Ampere's, he found he could increase the effects by coiling the wire into a helix, and inserting the needles in the central opening. This was in September, 1820. In the same year Davy achieved substantially the same results in a similar manner. A little later Schweigger invented his "multiplier," by means of which he made the magnetic action more intense through increasing the number of the coils. The invention of the electro-magnet in the form which adapted it for its varied uses is still a matter of considerable doubt. The English claim it for William Sturgeon, who undoubtedly disclosed a practical electro-magnet in 1825, and who probably invented it two or three years earlier. It is certainly true that the disclosure of Sturgeon's

magnet set people to work upon the new device, and that the later improvements rest upon the original form which Sturgeon gave to it.

Everybody knows that the efficiency and utility of the electro-magnet depend upon the circumstance that soft iron becomes temporarily magnetic under the influence of this electric current, losing its magnetism as soon as the current ceases. In this respect it differs from steel, which retains its magnetism after cessation of the current.

By substituting for the steel needles within the helix, in Arago and Ampere's experiments, a core of soft iron provided with a suitable armature, we have practically the Sturgeon electro-magnet. And yet the difference is quite sufficient to mark the birth of an instrument which has an adaptability in the electrical arts altogether without a parallel. In another place I have called it the first of the electro-mechanical powers,—corresponding, say, to the lever among the strictly mechanical powers.

The Sturgeon magnet already possessed powers far beyond the little apparatus which Oersted has described for us. He states, I believe, that it had a lifting power of nine pounds. As improved by Moll, and afterwards by Henry, who wrapped the iron core with many coils of insulated wire, according to the principle of the Schweigger multiplier, the electro-magnet came to have a lifting capacity of many thousand pounds. By this time it was no longer inconceivable that electricity, acting through electro-magnetism, might do some of the world's heavy work, for which it has since shown its capacity. Since the time of the inventors named, the electro-magnet has been made of numberless weights and sizes and configurations, to suit the needs or the whims of whoever wished to say: "Do my work." Perhaps it was Mr. Brush, seeking a regulator for his arc lamps; or Ball, or Edison, trying to separate metallic iron from its ores; or Weston, looking for a special type of dynamo-electric machine; or Morse and Vail, puzzled over the best sort of receiving apparatus for their telegraph; or some inventor of an alarm, annunciator, or other signaling system for house or hotel, requiring a tell-tale device; or Sprague, needing a motor for electric elevators or electric street cars. The electro-magnet adapts itself to all these requirements with unparalleled perfection.

The story of Ampere's deductions from the Oersted phenomena is familiar, but the significance of it may profitably be dwelt upon, since it is the story of one of the most remarkable achievements of human genius. It has been told many times, and may here be rehearsed in the language of Professor Chrystal.

"Scarcely had the news of Oersted's discovery reached France," he says, "when a French philosopher, Ampere, set to work to de-

velop the important consequences which it involved. Physicists had long been looking for the connection between magnetism and electricity, and had, perhaps, inclined to the view that electricity was somehow to be explained as a magnetic phenomenon. It was, in fact, under the influence of such ideas, that Oersted was led to his discovery. Ampere showed that the explanation was to be found in an opposite direction. He discovered the ponderomotive action of one electric current on another, and, by a series of well-chosen experiments, he established the elementary laws of electro-dynamic action, starting from which, by a brilliant train of mathematical analysis, he not only evolved the complete explanation of all the electro-magnetic phenomena observed before him, but predicted many hitherto unknown. The results of his researches may be summarized in the statement that an electric current, in a linear circuit of any form, is equivalent in its action, whether on magnets or other circuits, to a magnetic shell bounded by the circuit, whose strength at every point is constant and proportional to the strength of the current. By his beautiful theory of molecular currents, he gave a theoretical explanation of that connection between electricity and magnetism which had been the dream of previous investigators. If we except the discovery of the laws of the induction of electric currents, made about ten years later by Faraday, no advance in the science of electricity can compare for completeness and brilliancy with the work of Ampere. Our admiration is equally great, whether we contemplate the clearness and power of his mathematical investigations, the aptness and skill of his experiments, or the wonderful rapidity with which he elucidated his discovery when he had once found the clew."

To understand Ampere's work as a logical sequence of Oersted's discovery, let it be remembered that each new advance in the evolution we have endeavored to trace involved new conclusions in respect to the nature of the force which moved the compass needle. Thus, though Oersted's experiments pointed out this force as probably magnetic, they did not show, as Arago's tests did, that the electric conflict would magnetize a hitherto neutral body. The magnetic nature of this stress or conflict being established by Arago, and it being recognized that electric currents were capable of exercising an influence at a considerable distance from the conductors forming their path of travel, the notion of comparing the mutual effects of currents in neighboring wires was not far distant. Ampere's investigations, therefore, concerned themselves not only with the mutual action between an electrical conductor and a magnet, but also with the action of the earth upon a current, and the mutual effect of currents in proximity to one another.

One of the remarkable things about Ampere's work, noted by Chrystal and by everyone else who has investigated the matter, is the rapidity with which he arrived at his conclusion. Ampere heard of Oersted's discovery on September 11, 1820. Seven days later he read a memoir before the Royal Academy of Sciences, discussing the new phenomena, and he continued the subject before the Academy on September 25, and October 2, 9, and 30 following. It is this series of papers, together with some later articles published during the three or four succeeding months, which form the basis of Professor Chrystal's eulogy, and they are now familiar illustrations of the great powers of the human mind.

They occupy about fifty pages of the *Annales de Chimie et de Physique* for 1820. It will be possible here to make only a very brief extract from that portion of the memoirs which contains some of Ampere's earliest conclusions, as follows:

"1. Two electric currents attract each other when they are moving parallel in the same direction; they repel each other when they are moving parallel in opposite directions.

"2. It follows that, when the metallic wires which they traverse cannot rotate in parallel planes, each of the two currents tends to bring the other into a situation where it will be parallel to it, and moving in the same direction.

"3. These attractions and repulsions are absolutely different from ordinary electrical attractions and repulsions.

"4. All the phenomena presented by the mutual action of an electric current and a magnet, as discovered by Oersted, come under the law of attraction and repulsion of two electric currents, as just now enunciated, it being admitted that a magnet is nothing more than an assemblage of electric currents which are produced by action of the particles of steel upon each other, analogous to the action of the elements of a Voltaic pile, and which occur in planes perpendicular to the line which joins the two poles of the magnet.

"5. When the magnet is in the position which it tends to take under the influence of the terrestrial globe, these currents are turned in a direction opposite to that of the apparent movement of the sun, the conditions being such that, when the magnet is placed in the opposite relation, so that those of its poles which look toward the terrestrial poles are of like kind with the latter, the same currents are in the direction of the apparent movement of the sun.

"6. The already known phenomena observed when two magnets act upon each other come under the same law.

"7. The same is true concerning the action which the terrestrial globe exercises upon a magnet, assuming the presence of electric cur-

rents in planes perpendicular to the direction of the dipping needle, moving from east to west underneath the said direction.

" 8. There is nothing more at one pole of the magnet than at the other ; the only difference is that one is at the left and the other at the right of the electric currents which give magnetic properties to steel.

" 9. When Volta had proved that the two electricities, positive and negative, of the two extremities of the pile were attracted and repelled according to the same laws as the two electricities produced by means known before his time, he had not thereby completely demonstrated the identity of the fluids set in action by the pile and by friction ; but this identity was proved, so far as a physical fact can be, when he showed that two bodies, one electrified by the contact of metals, and the other by friction, acted upon each other, under all circumstances, as if they had both been electrified by the pile, or by the ordinary electrical machine. The same kind of proof is found here respecting the identity of the attractions and repulsions of electric currents and of magnets. I have just shown to the Academy the mutual action of two currents ; the well-known phenomena respecting that of two magnets come under the same law. Taking this resemblance as a starting-point, one could only prove that the electric and magnetic fluids are subject to the same laws, which has long been admitted ; and the only change necessary to make in the ordinary theory of magnetization will be to admit that the magnetic attraction and repulsion ought not to be compared to those which result from electric tension, but to those which I have observed between electric currents. Oersted's experiments, in which an electric current also produces the same effects upon a magnet, prove still more that it is the same fluids that act in the two cases."

The list of those who have in more recent times made fruitful studies concerning electro-magnetism would include more names than can find a place here. But Maxwell, Dub, Joule, De la Rive, Faraday, Rowland, Helmholtz, and Thompson deserve mention in particular. The last-named electrician has lately published an extended work on the electro-magnet, which summarizes the results of scientific research on this subject down to the early nineties.

THE CONTROL OF THE LEVELS OF THE GREAT LAKES.

By W. A. Jones.

WITHIN a reasonable time the Mississippi river may be expected to have another ocean outlet *via* the Great Lakes and the Illinois river. There is little doubt that such an operation would lower the level of Lake Michigan,—but how much can only be guessed at. The normal lake level, resulting from climatic influences, is a function of the relation between the rainfall over an imperfectly-defined area and the run-off, or quantity which gets into the streams and lakes. We are not at present equipped with the necessary facts to enable us, even approximately, to state that relation. The water-shed area cannot be precisely stated, and the average rainfall over it is not known. Actual measurements of rainfall are good only for small areas around the points of observation. The difference in precipitation between points not more than thirty miles apart is often considerable. The phenomena which control the relation between the quantity of water that falls as rain and the quantity thereof that gets into the streams are numerous and hardly amenable to precise observation and analysis. A rainfall of one inch may find the earth and atmosphere under such conditions as to absorb all, or nearly all, of it, on the one hand, or very little of it, on the other. Two inches of rain may fall within an hour, or may drizzle along for days in an atmosphere of high evaporative capacity. These are but items in a long category.

So far, our deductions in this matter have been based upon averages. But averages are not what we want. They are rarely, if ever, true statements of what has happened. The truth lies on one side or the other. Commerce on the lakes must be able to cope with something approaching minimum conditions. Where shall we go for the facts on which those conditions depend? Lake levels oscillate between upper and lower limits dependent upon widespread and complex climatic effects. Who can say that either limit has been observed and recorded? The once fertile plains of Babylon are blistered with desert heat. Will the oscillations of climate ever restore them? The lake beds of Minnesota and Dakota furnish evidences of a time of far less precipitation than that shown by any of our records. Why not turn aside from the mist and haze of meteorology, and consider a straight engineering proposition of laying our hands on those waters

and controlling their levels to suit our needs? I believe the lake outlets can be occupied with dams having gates in them through which such greater or less quantities of water may be allowed to pass as will enable the lake surfaces to be held each at a constant level. This level need not be higher than the waters have commonly reached before, and so no damage need be inflicted upon riparian interests. If this could be done, climate could go on its wonted way without filling the commercial mind with anxiety. The Chicago canal could be freely permitted to draw off its ten thousand cubic feet per second without creating apprehension. Consider the effect of giving the valley of the Mississippi two water lines to the markets of the world; of giving the great forests of its lower part a practical connection with the greatest market for manufactured lumber in the world; of raising its beds and mountains of iron ore to bessemer grade by means of ores from Lake Superior; of enabling lake vessels to figure with precision on their working draught.

Suppose a pool of water into which more water is being uniformly introduced. If not already full, it will gradually fill and overflow, until the whole quantity that comes in, less that evaporated, will be discharged at the outlet. The quantity passing out, supposing the discharge to pass through a rectangular notch, will be a function of

$$C\ b\ d\ \sqrt{2\ g\ h},$$

b and d being its breadth and wet depth, h the head on sill of the section, and C a constant. Now, if we deepen this notch, or section, so as to permit objects of greater draught to pass through it, we increase its discharge capacity, more water will pass out than is coming into the pool, and its level must lower until d becomes small enough to equalize the inflow and outflow. If, however, when increasing d, we decrease b in the proper proportion, the discharge and navigable capacity of the section will remain unchanged. With this state of affairs, if more or less water comes into the pool, its level will rise or lower, and the navigable depth of the outlet will increase or decrease in proportion. It is obviously impossible, with a varying quantity of water coming into the pool, to maintain a navigable channel of constant depth at the outlet. The best that can be done is to ascertain the minimum quantity that any season will supply to the pool, and, for a minimum navigable draught, to adjust the discharge section to that. Passing from pool to lake, it may be observed that the substitution of an actual river wet section at a lake outlet will not materially alter the foregoing general deductions. The play between vertical and horizontal causes and effects will be somewhat modified, but the main results will remain the same. Here again, however, we are face to face with the uncertainty of meteoric conditions. There is no

good reason for supposing that we have record of either a maximum or minimum run-off season, but strong indications that we have not.

Now, to adapt this principle to the interlake channels, let us suppose that we have two pools, or lakes, connected by an ordinary river-channel, through which one discharges into the other. The foregoing discussion, which applies in a general way to sections of river shape, of the discharge at a pool outlet applies to the various points along the river where there is a restricted navigable capacity. If at such a point the section is narrow, with obstructions, a pool will form upon it, until such head is created as will force the passage of all the water that comes. If we remove the obstructions or deepen the section, its navigable and discharge capacity will be increased, and the pool will be lowered. But, if, at the same time, we restrict the width in proper proportion, the two will remain relatively the same. There are cases where the navigable depth is below grade on account of the discharge taking place through a wide, but shallow, section. Operations for improvement here must be confined to deepening and restricting it. If we deepen it alone, a new and lower water surface will be created. The improvement will not be measured by the increased depth given to the section. The navigable capacity of a river is ruled by its minimum sections rather than by its average slope. It is a function of:

(1) The area of its minimum and wide-shallow sections;

(2) The quantity of water which seeks passage.

As before stated, we can measure the former, but cannot, with any sort of precision, determine the latter. Obviously, if we do something towards creating on the Great Lakes and their river connections a more uniform navigable depth,—something that will not leave their stupendous commerce restricted within the *ignus fatuus* lines of meteorology,—we shall greatly further the public welfare.

On all ordinary water lines of transportation created by modifying natural water-courses, the fluctuations of navigable capacity resulting from climatic changes have to be submitted to. Commerce must adapt itself to them, and there is always an element of uncertainty as to how much freight a vessel will be able to carry in the low-water season. The commerce of the Great Lakes, however, is so enormous,—far surpassing that of any other locality in the world,—and its development in proportion to the growth of the whole nation is so probable, that it is a matter of great importance to eliminate as much as possible of this element of uncertainty. I purpose to indicate a line along which we may hope to make such improvement. There are two distinct phases to the question:

(1) The navigable capacity of the lake harbors;

(2) That of the interlake channels.

The level of the water surfaces of the lakes varies with the run-off from their watersheds. I have before me the records of lake levels from 1836 to 1896. The oscillations in each yearly period afford a striking picture of the resultant of precipitating, evaporative, and other absorptive forces. From the lowest point in midwinter or early spring to the highest in midsummer, they follow each other with absolute precision. They reveal a climate where the bulk of annual precipitation occurs before midsummer. These double annual fluctuations from low to high and back again are ordinarily from one to two feet in extent, and occasionally between three and four feet. The extreme oscillation between highest and lowest recorded observations is from —1.5 to +4.0 on the gage. Here is a vertical oscillation, from actual measurement, of 5.5 feet. If we assume a minimum level based on these observations, and create entrances to the lake harbors measured from that, we may certainly expect periods of uncertain duration when the navigable depth of these entrances will be below grade. As the matter stands now, this is as much a meteoric question as one of engineering. It is quite evident by this time that, by the method of running out piers from shore and deepening the channels between them, we cannot, with any sort of precision, ascertain what the navigable depth of these harbor entrances is going to be from year to year. Commerce must take its chances, accept what it gets, and make its estimates in the midst of each season's battle.

In the interlake channels we have precisely the same meteoric uncertainty to meet. Here, however, it is aggravated by the fact that the United States has not the right to interfere with the levels of the pools of the lakes or the subsidiary river pools without the acquiescence of the Dominion government.

The existent projects for the improvement of lake harbors have for their object the creation of sheltered holding ground and channel entrances, and navigable depths in the same below an assumed low-water plane. For the interlake channels they seek to give a 20-foot navigable depth by increasing the minimum sections vertically and to a width varying from 300 to 2,400 feet as follows:

In St. Mary's river, at Hay lake, Round island, Little Mud lake, Sailors Encampment, and Mud lake, channel 300 feet wide and 21 feet deep.

At the foot of Lake Huron, channel 2,400 feet wide and 21 feet deep.

St. Clair Flats, from deep water in river to the St. Clair Flats canal, a channel 20 feet deep and converging from 650 feet wide at river to canal width at canal.

Through the canal, 20 feet in depth.

From foot of canal to deep water in Lake St. Clair, a channel 20 feet wide and diverging from canal to a width of 800 feet at deep water.

Foot of Lake St. Clair, channel 800 feet wide, 20 feet deep.

Lime Kiln crossing and vicinity, Detroit river, channel 440 feet wide and 20 feet deep.

Mouth of Detroit river, channel 800 feet wide and 20 feet deep.

In the presence of this description of the projects, and the foregoing general discussion, it is evident that we can make a great improvement by eliminating as much as possible of the purely meteoric factors of the problem. A discussion of the observed lake levels should evolve a desirable one for each lake, by holding which constant, or nearly so, the harbor question would be completely solved. I would occupy the outlet of Lakes Superior, Huron, Erie, and Ontario, with great dams having ample discharge capacity controlled by movable gates. These gates, or weirs, could be set at varying heights to control the levels of the waters above them. The new American bear-trap weir has come just in time to enable us to solve the great problem of the lakes. It will enable us also to store sufficient of the surplus water in the lakes as reservoirs, to be always ready to supply any deficiencies in the interlake channels, and, should it at times become necessary, to furnish what may be wanted for the discharge of the Chicago canal. These gates have passed the domain of experiment. Very large ones have been in use on our northwestern rivers for several years. Fig. 1 is an illustration of one designed to control an opening 16 feet in height by 600 feet in width. They can, by a mere operation of the filling or discharging valves handled by one man, be made to carry their crests indefinitely at any desired level within range. Such a dam would, of necessity, require a free discharging capacity about equal to a minimum discharge in its locality. Then, with a part of the water going through the free opening, and a part over the crests of the movable weirs, if more water should come into the controlled area, the weirs could be lowered sufficiently to permit it to pass without raising the level. If less water should come, the weirs could be raised, and the level of the controlled area would have to hold up until such increased head was created as would enable the coming water to get through the restricted area of discharge through the dam. Vessels going down could pass through the free opening without unreasonable difficulty, but those going up would have to be locked through the dam. The locks would have a very low lift, and should not cause much detention, especially if arranged as a pair, one for up-going and the other for down-going vessels.

I have made passing allusion to the international aspect of the

proposition herein advanced. Perhaps the greatest stumbling-block in the way of the necessary concert of action is the conception of a military frontier between the United States and Canada. A considerable portion of the boundary line is merely an astronomical conception. A great circle from the highest heavens, by subtle processes of mathematics, has been projected upon the surface of the earth as a dividing line. It is laid out on the ground by means of imaginary lines connecting certain monuments erected by the joint efforts of the two governments. From one side to the other there is little change of geographical features or industrial possibilities. As a matter of fact, the real boundary is not a line. It is a zone on the American side. The number of Canadians living within that zone is surprising. That silent zone is an everlasting protest against the boundary, against the idea of anything militant existing along it.

And more. By an irresistible law of strategy the people on the other side of that border zone are of a common destiny. Canada is an untenable position for England in the event of a serious clash with the United States. The development of transportation and commerce has revolutionized the strategic conditions along that border. Into and behind the English position there has been thrust the great throbbing heart which controls the pulsations of the inland commercial systems. As a result, any portion of the land forces of the United States can be projected with marvellous rapidity upon the rear of it, and thereafter have ample and secure communications. Why not have a show of hands right here, and end this talk of fight and defence in that quarter? Why not terminate the antiquated discussion about warships on the lakes? We want none there, and can see that no others get there.

Again, the vaunted position of Vancouver island, at the western extremity of the boundary, is also untenable against the United States. Within the sweep of a definite radius swinging around the little cluster of San Juan islands lies the strategic control of the North Pacific ocean and the western coast of the United States. At the point where Puget sound, the Straits of Juan de Fuca, and the Gulf of Georgia come together, a well-protected harbor can be created, having ample facilities of ingress and egress, and here the land and sea power of the United States could be brought together with ease and certainty. As a means of attack or defence against the United States it seems like waste for England to spend money for war purposes in that quarter. The conception of a military frontier between the United States and Canada has no just or solid foundation, and should not be allowed to stand in the way of a long pull together to make the unsalted seas a means of carrying old ocean's commerce into the heart of a continent.

THE RECENT PROSPERITY OF BRITISH RAILWAYS.

By William J. Stevens.

THE results generally displayed by British railways for over eighteen months past have fully justified the hopes of those who, prior to 1895, looked for better things from the companies than they were able to show in the bad years 1893 and 1894. The sudden change from a succession of poor dividends to a period of prosperity which has been witnessed since June 1, 1895, is without parallel in the modern history of the railways of Great Britain. Coming as it did after the exceptionally poor exhibits made in the years 1893 and 1894, as well as in the first six months of 1895, the sudden improvement was, of course, the more acceptable to the shareholders, who, since 1889, had had to bear a practically continuous decline in their profits from year to year.

From 1885 to 1889 was a period of successive improvements in the dividends paid by most British railways, culminating in the distributions of the latter year, which were rather above the average. But after 1889 there followed a number of bad years, each worse than its predecessor, which culminated in the unprecedentedly low dividends of 1893 and 1894. The former of these years was a record one, as regards the paucity of railway profits and the correspondingly low distributions on the ordinary stocks, due, of course, in a large measure, to the protracted strike of coal-miners in the second part of the period, which, besides paralyzing goods and mineral traffic in the Midlands, imposed on all the leading companies an unusually heavy charge for fuel. The succeeding year was rather better than 1893, so far as the English lines were concerned, but for more than three months of that period the Scotch companies had to endure a strike among the coal-miners in the districts served by them, which, so far as the area affected is concerned, was quite as disastrous as the English strike of 1893. The year 1895 was one of mixed influences counteracting each other, so that, on the whole, no material improvement took place. In the first six months both passenger and goods traffic (particularly the former) was adversely influenced by the severe weather then experienced. In the second half of the year the improvement in trade materially helped the companies, and for that period there was a general increase in dividends; but it did not in most cases do much more than make up the deficiencies of the preceding half-year. As a matter of fact, three large companies, the Great

Western, Midland, and North Eastern, each paid lower rates on their ordinary stocks for the whole year 1895 than for 1894.

But 1896, in decided contrast to previous years, was, throughout, a year of marked prosperity for all British railways. Everything seemed to assist them to increase their profits. A very large growth in gross receipts was secured, and continued throughout the year. On the other hand, expenses, though showing large increase, did not call for a relative share of the additional gross earnings, so that net revenue showed very large expansion. Then, to complete the favorable circumstances to the ordinary shareholders, the addition to capital charges during 1896 was remarkably small, so that a very large proportion of the addition to net earnings was paid away in increased dividends on the ordinary stocks. For the three years preceding 1896 the aggregate capital outlay of twenty companies was as follows:

Year.	Expenditure, 20 companies.
1893	£13,165,000
1894	9,977,000
1895	7,568,000

The comparative saving arising from the restricted capital expenditure prior to 1896 was augmented by that arising from the constantly declining rate at which the principal British railways can raise money, thereby accounting for the small increase of capital burdens in 1896.

With the combined force of the favorable conditions referred to above, there is little wonder that there was a large and universal increase in the dividends paid by the companies for 1896. The extent of the recent increase in dividends may best be seen by comparing those paid for the years ended June 30, 1895, and December 31, 1896. Subjoined is a comparison, on this basis, of the distributions made by the principal companies on their ordinary stocks.

Company.	Dividend for year ended June 30, 1895.	Dividend for year ended December 31, 1896.	Increase.
Caledonian	3⅞	5	1⅛
Great Eastern	1½	3⅛	1⅝
Great Northern	3¼	4⅛	⅞
Great Western	4⅜	6	1⅜
Lancashire and Yorkshire	4⅛	5⅜	1¼
London and No. Western	6	7⅛	1⅛
London and So. Western	6	6⅝	⅝
London, Brighton and So. Coast	5¾	6⅜	⅝
Midland	4⅞	6	1⅛
North British	2¼ Deferred nil Deferred	3 * 1⅛	¾ 1⅛ 1⅞
North Eastern	5⅜	6⅜	¾
South Eastern	4	4 1/16	1/16

* Estimated result to January 31 last.

It will be observed that during the past eighteen months the additions to the dividends paid range from ⅝ to 1⅞ per cent. in the case of the twelve leading English and Scotch companies. Among the smaller lines the improvement was equally good, while no company suffered any decline in distribution for 1896 from that of 1895.

The large increase in gross earnings during 1896 may be gathered from the fact that the gross receipts of thirteen leading companies for the period were £68,893,000 against a corresponding figure of £65,619,000, thus showing an increase of £3,274,000, or about 5 per cent. Working expenses showed an advance in the case of the same companies of £1,583,000, or considerably less than 50 per cent. of the additional gross receipts. The effect of this smaller relative increase in working charges was to reduce the ratio of expenses to receipts for the year by ¼ per cent. as compared with the preceding year. After meeting the increased cost of working, the addition to net earnings was £1,691,000. Of this sum no less than £1,576,000 was actually distributed in increased ordinary dividends by the thirteen companies in question, besides which the sums carried forward to the present year show, in several cases, substantial increases. As a matter of fact, the addition to the capital charges during the past year was only a little more than £100,000,—the smallest increase in this item for many years.

The effect of the improvement in net earnings last year has been to very materially improve the current yield on the capital invested in British railways. As the returns for 1896 are not by any means complete for all the railways of Great Britain, it is at present quite impossible to take a complete survey of the results in this respect; but it will not be difficult to show clearly that a distinct step forward has been taken. For the seven years prior to 1896 the board of trade statistics show the net return on the capital invested in all British railways to have been as follows:

Year.	*Net return on capital.*
1889	4.21 per cent.
1890	4.10 "
1891	4.00 "
1892	3.85 "
1893	3.60 "
1894	3.77 "
1895	3.80 "

As I pointed out in THE ENGINEERING MAGAZINE of August last, the figures given above do not allow for nominal additions to capital, which at the end of 1895 amounted to £88,500,000 out of a gross capital of £1,001,000,000. As a very large proportion of this nom-

inal increase accrued between 1889 and 1895, the decline in the net return was really not so large as it is made to appear. Allowing for this feature, the real decline in the return between 1889 and 1895 was probably not much more than .21 per cent. As dividends have practically been restored to the level of 1890, it is probable that the average net return on the whole capital of the railways of the British Isles will, when the returns are fully complete, work out at about 4.10 per cent. as in 1890, after allowing for the merely nominal additions to capital made in the interval.

For the purpose of ascertaining exactly what progress has been made in the matter of the net return yielded on railway capital in 1896, the actual results of the thirteen leading companies already referred to may be taken. To the end of 1895 the total capital of these thirteen companies, excluding nominal creations, was £618,000,000, and, as the net revenue for the year amounted to £29,214,000, the average yield on the capital invested was 4.73 per cent. At the end of 1896 the total capital of the same companies had increased to £625,700,000, and the net revenue to £30,905,000. The latter figure represented a yield on the capital of 4.94 per cent., an improvement as compared with 1895 of .21 per cent. As the whole of this improvement has gone solely to the ordinary stock-holders, it represents a much larger relative increase on the ordinary capital. Thus, while the total improvement on the net revenue of 1896 amounted to 6 per cent. as compared with 1895, the amount distributed in dividends on the ordinary stocks showed an increase of 15 per cent.

With this general as well as large improvement in the position of the ordinary stocks of all British railways, there is little wonder that the prices of the latter have recently been very high,—record figures in some instances. Not only have dividends already been materially enhanced, but prospects continue to be good, for traffics are still showing progress, and yet further increases in dividends may be realized. A curious feature in connection with the present level of quotations may be noticed at this point. Taking the whole list of British railway junior stocks, the yield on the basis of present prices is materially higher than it was a year ago, taking the prices then ruling and the dividends for 1895. The reason for this is that the level of quotations at the earlier period discounted to a considerable extent the improvement which has now been actually realized, and the prospect of further improvement is of course not so great. Another point in connection with this phase of the subject is that prices are now, in most instances, materially lower than they were six months ago, though in the interval marked increases in dividends have, as already indicated, been secured. For the decline in the face of improved re-

sults, the tendency to over-discount future improvement, which is a characteristic of the stock markets, is largely accountable, though an improvement in the rates ruling in the money market, after a period of abnormal cheapness, as well as recent political unrest, have also been adverse features tending towards lower prices.

In spite of the fact that during the last few months the return on an investment in the junior stocks of British railways has increased, owing to the increase in dividends, on the one hand, and a slight decline in market values, on the other, there is no doubt whatever that the present yield is still low, compared with former years. On the basis of last year's dividends the yield at the present time ranges, according to the character of the stock, from 3 to 4 per cent. on the junior securities, and averages about 3½ per cent. As last year's dividends were, in nearly all cases, rather above the average, the continuous yield which may reasonably be looked for is even less, and does not exceed 3¼ per cent., taking the regular dividend paying stocks together There are a number of the more speculative stocks which yield less than 3 per cent., even on last year's dividends, while a few yield nothing whatever. These, however, always command a relatively high value on account of the speculative favor in which they stand, partly because their low price attracts buyers, and partly because a stock receiving no dividend, or only in receipt of small and irregular dividends, is difficult to value with any precision. Prospective rights carried by them are certainly of some value, but, as in the case of those American railroad common stocks which have, up to the present, been dividendless, a relatively high price is given, even in poor years, for the rights they carry, as contrasted with superior stocks or bonds, ranking ahead of them and actually in receipt of regular income. Stocks of this kind may, however, be disregarded in examining the present yield on the ordinary stocks, for they represent but a small proportion of the total, especially having reference to the market value of the capital involved. As evidence, however, that the rise in railway securities which has brought about the marked diminution of the yield in recent years has, for the most part, resulted from an investment demand, it may be pointed out that the non-dividend stocks and those in receipt of irregular distributions have not by any means reached the comparative heights attained by those stocks in receipt of large and steady dividends.

The high prices of all British railway securities are simply the result of the action of the law of supply and demand. Had the yield on these stocks shrunk as it has done while that obtainable from other securities had remained stationary, the position would indeed be dangerous, and foolish would be those investors who should venture to

face the risks such a position of matters would imply. But the relative superiority of the yield afforded by railway stocks is as great now as it was when "Consols," by example, yielded 3 per cent., although now the latter security yields only 2 per cent., allowing for the fact that the interest declines to 2½ per cent. in 1903 and also for the disappearance of the premium in 1923, when the stock is redeemable at par. All securities of a sound character yield materially less than they did only a few years ago, and the high prices of railway stocks are due to the fact that they have shared in that movement, and nothing more. Whether *all* high-class securities have not appreciated unduly in recent years is a question which it is not necessary to discuss in connection with this matter. A great difference of opinion exists regarding it, though the view of most people capable of judging is that all these stocks must sooner or later come down to a lower level. A great war, a financial panic, or a material advance in money rates would suffice to bring all these securities down from the inordinate heights to which, as the result of a long period of appreciation, they have attained. But surely, granting that such a change must come, it will be admitted that the stocks yielding most at the present time, and withal enjoying good security, will suffer less than those which, yielding a lower return, therefore present a much more vulnerable front to the disturbing influences of a wave of depreciation. This is one great reason why the really good ordinary stocks of British railways are so much sought after at present, and, from the point of view of the permanent investor, who buys a stock in order to obtain as good an average yield as possible, there is much to be said in favor of it, especially while prospects continue good.

As an example of the choice that is before the investor at the present time, let us examine the comparative inducements to purchase, say, London and North Western debenture stock, on the one hand, and the ordinary stock of that company, on the other. In the former case he buys a 3-per cent. stock at 118 per £100, which yields him £2.10.10 per £100. There is no prospect whatever of any improvement on that yield, as the stock is entitled to a fixed rate only, and practically no risk that the return will be diminished. Since 1889 the stock has appreciated by 22 per cent., and, though the quotation was last year as high as 125, there is, on the whole, greater risk of loss than prospect of gain in capital value. As regards the ordinary stock the investor would be able to secure at about 200 per £100 a stock that yields on the basis of last year's dividend £3.11.3 per £100, or 1 per cent. more than on the debenture stock. On the basis of the average dividend for eight years past, the yield would be £3.9.0 per £100. There is the prospect this year of a further improvement in the dividend. Since

1889 the market value of of the stock has increased on balance by only 11 per cent., so that there appears to be greater reason to expect capital gain than loss at the moment, especially with a higher dividend in view. Taking all the facts into consideration, it must be admitted that there is much to be said in favor of the superiority of the ordinary stock as an investment. And the contrast drawn between the debenture stock and the ordinary stock of the North Western Company might be with equal force applied to an estimate of the comparative merits of a purchase of "Consols," colonial stocks, corporation stocks, and other high-class securities, on the one hand, and the better class of railway ordinary stocks, on the other, for in all cases the additional risk incurred by the latter is more than compensated by the higher yield, and smaller prospect of capital loss.

Up to the present the comparative merits of the ordinary stocks have been mainly considered. Their positive advantages remain the same as those which, by long experience, the British investor has proved them to possess. Good and honest management of the companies on which they depend, both commercially and financially, is their strongest point. Then, while under a considerable amount of supervision by the State, through the board of trade, they are comparatively free from harassing legislation, such as has been witnessed in America. The success with which the railways have lately been able to meet in the courts of law various questions in regard to rates has amply vindicated the strength of their legal rights. The long-continued rates-agitation of late years has failed in its purpose of cutting down the charges made by the companies, and has yielded to those who pursued it only apparent advantages in the matter of reduced maximum rates, which have had little practical value, though the companies, on the other hand, have been able, in the course of the consideration of the matter by parliament, to legalize charges (notably terminals) which had not previously the unquestionable sanction of the law. There is no danger of State purchase on Socialistic lines; the public sense of justice would not entertain for a moment any confiscatory measure of this type. As a matter of fact, State purchase is regarded as a purely academic proposition, and there is no appreciable section of public opinion in its favor.

Another great point in favor of English railway stocks is that the companies are free from the disastrous rate-wars which inflict such injury on American railways. The laws of Great Britain do not forbid pooling arrangements, and, as comparative harmony exists among the companies in the matter of charges, a war of rates is in any form a very rare occurrence indeed. It may be said that the trading community of Great Britain suffers as contrasted with their brethren in America from the higher charges which result from the absence of

rate-wars. But many authorities are of opinion that what is most conducive to the public interests is a steady maintenance of rates at a moderate level rather than the sharp fluctuations in charges due to untrammelled competition. Certainly it may be said that the trading public do not really benefit to anything like the extent that railways suffer in a rate-war. To the maintenance of rates and fares the clearing-house system in Great Britain very materially contributes. It is a well-established, independent organization supported by the companies in the proportions of the work done for them, and, besides dividing receipts from through traffic among the companies, it is a most valuable check on undue competition in rates and fares. The interests of the public are by no means neglected in this matter, and, as evidence that this is so, reference may be made to the reduction of fares lately instituted by several companies to check the decline in second-class traffic. From the beginning of 1895, for example, the South Eastern & Chatham Companies materially reduced their first- and second-class fares. Last year the Great Western and South-Western took similar action, and reduced their second-class fares considerably. According to the general basis on which their fares were framed, the charges were at the rate of twopence a mile first-class, three halfpence a mile second-class, and a penny a mile third-class. Under this scale there has been a constant drain to the third-class, due, no doubt, to the great improvement in the accommodation there given as compared with the superior classes. This was especially the case with the second-class; so the plan of reducing these fares to a penny-farthing a mile (only 25 per cent. more than the third-class) was decided upon, and its introduction in May, 1896, has already yielded a very satisfactory result in the case of both the Great Western and South Western companies. The Brighton Company intends to reduce its first- and second-class fares to the level of two-pence a mile and a penny-farthing a mile respectively, beginning May 1, 1897, maintaining a penny a mile third-class, as at present.

Though competition in rates and fares is alien to the working of British railways, another form of rivalry which, though costly to the companies, is of great benefit to the public, is the competition to improve and increase facilities, both as to speed and accommodation. In recent years this kind of rivalry has made great strides, and to it the increase in the ratio of expenses to receipts is largely due. It is in passenger traffic that its working can be most clearly traced. During recent years there has been a great increase in the accommodation provided in the direction of dining- and drawing-room cars, sleeping saloons, corridor carriages, etc. Even the third-class passenger on the principal trains to Scotland is provided with a dining-car without

extra charge beyond that for meals. These additional facilities materially increase the dead-weight of the trains and reduce the earning capacity per train-mile. In addition, the speed of many trains has been increased, involving addition to the cost of working. To haul the heavier trains, more powerful and weightier engines have been constructed, which, together with the high speed maintained, entail a more expensive permanent way. At the half-yearly meeting of the London & North Western Company, the chairman, Lord Stalbridge, referred to this matter. He said: "Owing to the increase in the weight of trains, the speed at which they run, and so on, it has been thought desirable by our engineer to increase the weight of rail. Up to 1885, the 84-pound rail was thought to be heavy enough. In 1885, however, we commenced to lay a 90-pound rail, and that has gone on up till now. We now propose to lay a rail weighing 103⅓ pounds per yard." This, of course, entails an addition to the cost of working, due to this competition of facilities. Under these circumstances it is hardly surprising that the average rate of working expenses has increased since 1889 from 52 to 56 per cent., especially taking into account the addition to such items of expenditure as wages, rates, and taxes. By reason of superior management the effect of this increase in the ratio of working expenses is being overcome, and, as it may be regarded as having, in some respects, reached its limit, there is little danger of ordinary dividends being affected. The lower cost at which the companies now raise capital may be taken as entirely counteracting this.

The most reassuring point about British railway stocks, and one which, above all things, commends them to the favor of the investing public, is the straightforward character of their financial administration. Receiverships, reorganizations, assessments, scaling down of interest on income bonds, and even on mortgage bonds, which so seriously prejudice capitalists against American railroad securities, are phrases which have no application so far as holders of British railway securities are concerned. Railways in Great Britain are not managed with one eye on the stock markets and the other on the interests of their proprietors. A manager who attempted to do anything of the kind would soon have to face dismissal by the board of directors, and anything like disregard for the interests of the proprietary on the part of the latter, with a view to speculative effects, would secure even their expulsion at the hands of the shareholders, who would know how to use, when necessary, the power conferred upon them by the laws of the land. Under these conditions the high prices now current for British railway stocks are not difficult to account for; indeed, it would be surprising if matters were otherwise.

THE CURE FOR CORROSION AND SCALE FROM BOILER WATERS.

By Albert A. Cary.

III.

HAVING considered the corrosive agents found in boiler waters, and also the individual characteristics of the scale-producing substances, we are now prepared to examine these collectively, and then proceed to a consideration of the various methods for their removal or treatment.

The hardness or softness of water, for boiler purposes, depends entirely upon the quantity of lime or magnesian salts in solution. There are two kinds of hardness in water,—"temporary hardness," due to the carbonates of lime or magnesia held in solution by an excess of carbonic acid, which can be gotten rid of by any method that will drive this off or neutralize it, and "permanent hardness," due to the presence of any soluble salts of lime or magnesium, such as the sulphates, chlorids, and nitrates, held in solution by the solvent properties of the water itself.

The "total hardness" is best distinguished by the fact that, when soap is used with hard water, a certain proportion of it will be destroyed before a lather can be produced, this amount being in direct proportion to the degree of hardness of the water. This destruction is due to the decomposition of the soap by the lime or magnesian salts, and the formation of an insoluble curd of oleate, palmitate, and stearate of lime, or magnesia. By using a sufficient amount of soap the water can finally be softened so that a lather can be formed, but this is a very expensive process, as, according to Collet, the lime salts in a thousand gallons of water will destroy 1.7 pounds of the best hard soap for each "degree of hardness" in the water, one such degree being equivalent to one grain of carbonate of lime per gallon, or its equivalent in soap-destroying power.

Stillman gives (in his "Engineering Chemistry") the following instructions for the determination of the hardness of water.

(1) The preparation of a standard solution of "hard water." "Dissolve 1.11 grains of pure fused calcium chlorid in a little water, and dilute to 1 liter at 60° F.; . . . each cubic centimeter of the solution will correspond to 0.001 gram calcium carbonate."

(2) Solution of soap. "Thirteen grams of sodium oleate are dissolved in a mixture of 500 cubic centimeters of alcohol and 500 cubic centimeters of water, and filtered if necessary." "It now be-

comes necessary to standardize it, so that one cubic centimeter will be equivalent to 0.001 gram of calcium carbonate." This is effected by taking a definite volume of the standard hard water just prepared, measuring accurately the amount of soap solution which must be added before a permanent lather is formed, and then diluting the soap solution, if necessary, until it shows the proper proportionate strength.

(3) Determination of the total hardness. "58.3 cubic centimeters of the clear sample of the water to be examined are run into a 250-cubic-centimeter flask, and the standard soap solution added in the manner described above, until a lather capable of persisting for five minutes is produced." "The number of cubic centimeters required, minus one cubic centimeter for the water itself, will give the degrees of hardness in terms of calcium carbonate in grains per U. S. gallon." "If the water contains a fair proportion of magnesian salts, there will be some difficulty in obtaining the right point, owing to the slowness with which magnesia salts decompose soap; an apparent persistent lather is formed, which, on being allowed to stand a little while and again shaken up, will disappear; a little experience with magnesian hard waters will familiarize the operator with this peculiarity."

The "permanent hardness"—*i. e.*, that which is not due to the presence of the soluble bicarbonates of lime and magnesia—is determined by a substantially similar test made upon the water after boiling it for half an hour. The "temporary hardness" is the difference between the "total" and the "permanent."

"The French standard of hardness of water is stated in terms of milligrams of calcium carbonate in 100 grams of water, or, parts calcium carbonate per 100,000 parts of water."

"The German standard represents milligrams of lime in 100 grams of water, or, parts lime per 100,000 parts water."

"The English standard represents grains of calcium carbonate per gallon of 70,000 grains" (the imperial gallon).

"The American standard represents grains of calcium carbonate per gallon of 58,381 grains" (the United States gallon).

Scale, or incrustation in boilers, is formed by the settling of matter originally held in mechanical suspension, or, more frequently, by the settling of precipitations from chemical solutions.

As we have seen, precipitation from solutions is caused, first, by the expulsion of gases which, when present, held these matters dissolved, and, second, by the simple concentration of solutions beyond their point of saturation.

Incrustation, strictly defined, refers merely to hard crusts of boiler scale, but in boiler parlance it is made to include all precipitation oc-

curring in boilers, from the soft, slushy mud to the very hardest scale. The coherent crusts found in boilers differ widely in hardness and tenacity. Some of these may be crumbled between the fingers to a powder, while others form a hard, compact, porcelain-like scale, which resists the chipping tools or chisels even more obstinately than the very metal of the boiler itself. The scale is very seldom uniform in composition; it usually consists of successive layers, each differing from the deposit above or below it. Some scale is very porous, and the water and steam seem to have little difficulty in finding their way through it, while other scale is solid, compact, and entirely impervious.

The preceding article considered the most important scale-making matters, traced them back to their source of supply, and studied their individual characteristics. We now come to their behavior inside the boiler.

Free floating matter in boiler waters, to which reference was made in Part II of this article, is apt to make no little trouble, as in most cases it is composed principally of clay, which forms a cementing material for the matter already precipitated, so that the result is generally a hard scale resembling Portland cement. The size and character of the particles of earthy material differ considerably, and this governs their time of precipitation. After heavy rains, larger particles are generally found in suspension, while, when the source of water-supply has remained undisturbed for some time, this sedimentary matter often disappears entirely.

The larger and heavier the particles are, the more rapidly they will settle, but the finer particles will be held for a long time in suspension by the circulating currents of the boiler, and often will not settle until these currents are diminished, or cease altogether; this condition may be attained (in factories) during "noon hour," over night, or on Sunday. This will partially explain why boiler scale so often occurs in successive layers.

Vegetable matter is, of course, lighter than the earthy material, and therefore remains longer in suspension, but it finally settles when the water in the boiler is at rest, or nearly so. It also serves, in some cases, to bind the previous precipitate into a hard mass, while, in other cases, it prevents the formation of such hard crusts. Organic matter, as a general thing, discolors the scale, giving it a black or dark-brown appearance.

When the temperature of a solution containing the bicarbonates of lime, magnesium, or iron is raised to 180°, a considerable percentage of these salts is precipitated, while at a temperature of 290° the precipitation is complete. Thus it can readily be understood that the dis-

solved carbonates will be deposited in the boiler; but this precipitation is not instantaneous.

When a precipitation of carbonate of lime or carbonate of magnesia takes place, tiny crystals are formed, so minute that, notwithstanding their being specifically heavier than the water, they remain suspended for a long time before settling, especially when the circulating currents in the boiler keep them in motion. At this stage these crystals have no tendency to agglomerate, but remain floating freely in the water, like so much flour. When first separated from the solution, they generally rise to the surface of the water, forming a scum of more or less thickness and density; but gradually they seem to grow heavier, sometimes adhering to the other impurities in the water, and then they settle slowly to the bottom of the boiler, unless arrested in their course by tubes, or flues, or other boiler parts.

This settling takes place where the circulating currents are the weakest; when the boiler is put out of active service, and the circulation slackens and eventually ceases, it becomes general.

The soft, slushy mud which is thus produced will not form even a soft coherent scale, unless the boiler is emptied of its water while hot, in which case the heat from the boiler itself, or from the surrounding brick work, bakes the mud into a solid mass much more difficut to remove. If attacked while soft, it can easily, in most cases, be washed out with water from a hose or swept out with a brush.

The hard scale formed from this precipitate is a white, porous crust, having comparatively little tenacity. When these carbonates occur in considerable quantity in boiler waters, the water often becomes sensibly thickened by the precipitations, and this interferes not a little with the free escape of the steam. The action of the steam bubbles rising through this thickened water is not at all dissimilar to that occurring when we attempt to boil milk, mush, or oat meal. In such operations the cooks know that they must keep up a constant stirring to liberate the imprisoned steam and assist the convection. If such stirring is omitted, the contents will become attached to the vessel, and both contents and the bottom of the vessel itself will soon be burned. In the boiler the steam struggles similarly to reach the surface, where it finally breaks out with a small explosion, throwing upward with considerable force small drops of water along with particles of the suspended material.

In the boiler these often pass off with the outrushing steam, thus causing serious priming, or foaming, and many of the small globules of water entrained in the steam enclose a minute crystal of the solid matter. This is eventually dropped in the steam piping, or the valve chambers and cylinders of the engines; and thus we are able to account for the white, solid incrustations sometimes found in these places,

and also for some of the undue wearing of the valves, pistons, and their seats or bearings.

Concerning the effect of the deposit from such precipitations on the bottom of boilers, President Allen, of the Hartford Steam Boiler Inspection and Insurance Company, says: "It has generally been supposed that a deposit in a soft state caused little or no injury to a boiler; but our experience has proved conclusively that the contrary is true." . . . . "A deposit of slush or sludge collects on the bottom of boilers and around the seams, and, in fire-box boilers, around the furnace sheets and around the water legs." "The presence is detected by leakage at the seams, fractures at the edge of the plates and in the line of rivets, and by overheating and consequent depression of the plates where it rests." . . . . "This difficulty is greatly aggravated, if grease finds its way into boilers; the grease appears to combine mechanically with the carbonate of lime, and sinks on the plates when the boilers are at rest." "It becomes a loose, spongy mass, which is not carried off by the circulation; but, by its contact with the plates, it keeps the water from them, and, by offering resistance to the free transmission of heat, causes overheating and burning of plates." "Before we had fully investigated this subject, our opinion was, in many instances where boilers were leaking badly and showed indications of having been burned, that it was caused by the carelessness of the engineer in starting his fire with no water in the boiler."

Where the carbonates are present in boiler waters in any appreciable quantity, the blow-off cocks should be opened with more or less frequency, according to the amount of matter precipitated. The "surface blow" or scummer is effectively used to remove the scum from the surface of the water before it has time to settle, while the "bottom blow" is used to remove the mud from the bottom of the boiler. We will take up this matter in greater detail later.

We have thus far considered merely the soft friable scale formed by the precipitation of the carbonates alone; a much harder scale is frequently formed by mixture with other precipitated matter. Clay, settling with this salt of lime and magnesia, forms a cement-like mass; the hydrates of lime and magnesia, occurring with the carbonates, also cement them into a hard, compact scale, difficult to remove; but nothing seems to have so strong a binding effect upon them as the sulphate of calcium. Its long, fibrous crystals are frequently seen binding these carbonates into a solid compact mass, and, when these gypsum crystals lose their water of crystallization by the heat, and become anhydrite, the scale becomes all the more solid and difficult to remove.

When the carbonate of lime, or of magnesia, is precipitated in contact either with the hot metal of the boiler, or with hot piping, or with the previously-deposited scale, crystals are formed, which adhere to such surfaces with some tenacity.

From what has been said, it will be seen that, when a carbonate of lime or carbonate of magnesia scale (separate or together) is formed, some cementing substance must be present to bind it into its solid form, if it has not been *baked* into the crust.

We have considered carbonate of lime and carbonate of magnesia together, on account of their similar behavior; but lime is more frequently found as a carbonate in scale, not only because of its greater abundance, but also because the bicarbonate of magnesia is generally precipitated as a hydrate, forming a powerful cement. Should the hydrate of magnesia be accompanied with a precipitate of sulphate of lime, the hardest kind of scale will form. A scale of this kind, analyzed by Silvester, had the following composition:

	Percentages.
Carbonate of lime	2.490
Sulphate of lime	74.280
Magnesium hydrate	18.000
Alumina and oxid of iron	1.276
Silica	1.830
Organic matter	2.124
	100.000

This was a very hard scale, which had to be chipped from the plates.

The bicarbonate of iron is seldom found in boiler waters in excess of a grain per gallon. It is so very unstable that it is precipitated, the moment it enters the boiler, as hydrated oxid of iron; it is scarcely worth further consideration here.

Of all scale-formers doubtless none give greater trouble than the sulphate of lime. Its maximum solubility, as already stated, is at 95° F., while at a temperature of 302° it is practically insoluble. In consequence of this fact, whenever water containing this salt is fed to a boiler with 55 or more pounds' steam pressure, nearly all the salt is precipitated. The solution depends entirely upon the solvent power of the water itself, and not upon the presence of gases; the water, therefore, seems to part with the sulphate of lime more reluctantly, and considerable time is required to effect this precipitation by heat.

Very-low-pressure boilers may be operated without much trouble,

even when this salt is present, provided they are blown off sufficiently to prevent too great a concentration; but, even without this concentration, a certain amount of precipitation of sulphate of lime always takes place, causing more or less hardness in the scale.

The precipitated sulphate of lime appears in crystals somewhat larger and considerably heavier than those formed from the carbonates, and consequently settling much more rapidly. They form a semi-crystalline scale so hard and solid that it can be removed only by use of the chisel and chipping-hammer.

The binding effect of sulphate of lime upon other scale matter is due to a change in crystalline structure. This salt is precipitated in the form of small angular crystals as the hydrous sulphate of lime. As soon as it reaches the heating-surface, the heat drives off the water of crystallization, changing it to an anhydrous sulphate, at which time the crystals alter their form to a fine needle-shape. These adhere to each other, or else, scattered through the previous or accompanying deposits, bind them into a solid mass.

Some have stated that, owing to its solid, compact structure, sulphate of lime will transmit heat better than the looser or more porous scales; practice does not confirm this, as more burned tubes and plates are found under this hard scale than under the softer variety, unless the latter contain oil; of course, a great deal of such trouble must depend upon the temperature or intensity of the fire, a forced fire having a tendency to make any scale harder, and, of course, it taxes a given amount of heating-surface with a greater duty in transmitting heat to the water.

Silica is never dissolved in large quantities in boiler waters, and, therefore, as a rule, only a very small percentage of it is present in boiler scales, although it is contained in a majority, and often in combination with an equally small amount of alumina. Occasionally, when present in certain waters containing but little of the other impurities, it will accumulate in time, and form a large percentage of the scale. In such cases, after long runs without cleaning or blowing, it first forms a jelly-like paste, gradually changing under the effects of heat into a white, laminated mass with an undulating surface, which may be detached from the boiler surfaces by scraping. Finally, the heat bakes it into a hard, dense, resisting crust, which only hard chipping will remove. When this silicious jelly is deposited with other impurities in any appreciable quantity, it passes through the above-described changes, and tends to bind the mass into a hard scale.

Silica is easily precipitated by simply boiling the water at atmospheric pressure, and it is for this reason that we occasionally find it forming a considerable percentage of the scale in low-pressure boilers

where sulphate of lime is the principal other impurity. Chlorid of magnesium, owing to its instability at boiler temperatures, will gradually decompose and precipitate magnesium hydrate, the cementing effect of which, when mixed with other precipitates, we have considered. This salt, however, is soluble, and will remain in solution for some time before decomposing.

Practically speaking, we have now considered all of what Silvester classifies as "direct scale-formers" under ordinary working conditions. There remain for our consideration the "indirect scale-formers."

These consist of the various impurities in boiler waters which remain in solution under ordinary working conditions, and include the sulphate of magnesium and also the chlorids and nitrates of calcium, sodium, and potassium.

The individual characteristics of these salts have already been considered in the preceding article, and very little more remains to be said. It will be seen that they are all more or less soluble and are not precipitated unless by concentration of the solution; and, generally speaking, in the quantities usually present in boiler waters, they have very little effect upon the character of the scale.

After examining scale from boilers, many remark upon its stratified appearance, and ask why it is that such a variety of layers is found in a single specimen. This is easily explained.

The character of many feed-waters changes from time to time. In running streams, after rains, the water is often muddy while at other times it is clear. In large rivers, as, for example, along the lower Mississippi, the dissolved impurities are constantly changing, according to the geological character of the country from which the river receives its chief supply, this being regulated by flood and drought in the various sections forming its water-shed.

As these varying waters are fed to boilers, of course the deposited impurities must change. Well-waters also are likely to vary from time to time.

When several impurities occur in a boiler water, the kind of material precipitated depends mostly upon the temperature or degree of concentration. Thus, should we fill a boiler with water containing mechanically-suspended matter, this matter will gradually settle to the bottom, forming one layer; next, if the water be heated to 212°, much of the carbonates will be deposited; and, if afterwards the temperature be raised to 300°, the sulphate of lime will be precipitated. By neglecting to blow off the boiler, we may concentrate some one of the solutions of a very soluble salt beyond its point of saturation, when another precipitation takes place. During all of this time much light

floating matter will be held in suspension by the circulating currents, and, when we finally draw our fires and the water comes to a state of rest, this will settle, and another layer be formed.

To the experienced eye there is much instructive information in boiler scale, principally as to the manner in which the boiler has been handled. Little is to be obtained from it, however, to guide one in treating the boiler water, although it is frequently very useful when considered along with the water analysis; in this connection it is sometimes desirable to analyze the scale; but the more logical and useful course is to analyze the water before it enters the boiler.

The greatest deposit of scale seldom occurs directly over the fire in horizontal boilers, as the rapid circulation of the water above this part tends to keep the floating matter in suspension. These circulating currents always move toward a part of the boiler where the heat (in contact with the boiler surface) is less intense, and the movement of the water diminishes as it approaches such parts, thus allowing the floating particles to deposit. In consequence, we always find the thickest deposit where the heat is least intense, or where the water in the boiler is the quietest. Feed and blow-off pipes frequently hold water at rest for long intervals, thus allowing deposits to line their inner surfaces and reduce their size. These coatings are sometimes but a small fraction of an inch in thickness, while in other cases they may entirely choke up the pipe.

Scale of more or less thickness and hardness frequently forms around boiler tubes and other parts above the fire sheets. Expansion and contraction of the boiler, or the use of solvents which "rot" away such scale, cause it to fall in solid pieces. These pieces often lodge between the tubes, interfering seriously with the circulation of the water, but more frequently they drop upon the fire sheet and prevent the water from reaching that part of the sheet immediately beneath them, often resulting in serious overheating.

Sometimes, when a large number of these cracked-off pieces fall upon a lower sheet, and a deposit of scale-making material follows them, they are cemented into a dangerous crust.

It has been contended that a deposit of scale in a boiler is a good thing. This may be true of a deposit no thicker than an egg-shell, but only when the water contains corrosive agents which attack the boiler parts; and, in order to serve its purpose, the deposit must be evenly distributed over the entire surface to be protected, since, if a few small patches be left uncovered, the corrosive agents will concentrate their effort on these places. I have already spoken of the use of such a deposit where pitting is taking place.

It has been my experience that, where a slight scale is to be al-

lowed to protect the interior boiler surfaces, the man in charge is very apt to permit a much thicker coating to form than is desirable. This is often very dangerous; besides, with such a coating on the interior of the boiler, it is impossible to make proper inspection, such a scale frequently hiding serious corrosion and wasting.

The best way to overcome such difficulties is by a proper treatment of the water; then the dangerous scale will not be formed in the boiler.

I have often been asked "how many grains, per gallon, of scale-making impurities a boiler water may hold without being considered bad." A direct general answer to this question is almost an impossibility. So much depends on the nature of the impurities that their mere amount can hardly be a measure of fitness. A water may hold as high as fifty grains per gallon of some of the very soluble salts, and still be a very good boiler water, while the presence of one-tenth of this amount of sulphate of lime would cause considerable trouble. Silvester has attempted to make a general classification of this kind, as follows.

"Less than 8 grains of incrusting solids per gallon (carbonate of lime, carbonate of magnesia, sulphate of lime, chlorid of magnesium, etc.) ..... Very good

8 to 15	grains	per	gallon	Good
15 to 20	"	"	"	Fair
20 to 30	"	"	"	Poor
30 to 40	"	"	"	Bad
Over 40	"	"	"	Very bad.

In many steam plants the steam, after being used, is condensed, and the water thus obtained is fed back into the boiler.

Oil, which has been used to lubricate the steam cylinders, is often present in water so condensed, and it is probably the source of more trouble in steam boilers than any other feed-water impurity; certainly it is more difficult to remove or treat.

In ordinary practice, an oil cup or lubricator is screwed into the steam pipe very near the engine, and from it oil is introduced into the entering steam and carried by it into the cylinder, where the greater part of it is supposed to reach the cylinder walls, the piston rod, and other rubbing parts. The amount of oil thus introduced varies greatly in different plants, the conditions governing the quantity being the design of the lubricator, the design of the engine (some requiring more oil than others), and, last, but by no means least, the notions of the man who operates the plant (some engine tenders insisting on flooding their cylinders with oil).

When oil is thus fed into the steam, much of it doubtless enters the cylinder in the form of minute globules held mechanically in suspension, while the balance is changed to a vapor by the heat. The velocity of the steam entering the cylinder and that of the exhaust steam rushing out of the cylinder doubtless carries along with it a considerable percentage of the mechanically-suspended oil, and the fall of temperature between the times of admission and exhaust also, doubtless, causes some of the oil vapor to condense back into the liquid form again, and thus add to the amount of suspended oil in the exhaust steam.

A certain amount of the oil vapor must also pass off with the exhaust steam. Exhaust steam contains, too, a very perceptible percentage of condensed steam—*i. e.*, water—mechanically suspended, and the oil seems to be greatly attracted to the surface of these small particles of water, forming a film or envelope, which coats their exterior surface. We now have before us the three different forms in which oil occurs in exhaust steam,—namely, as solid globules, as a vapor, and as a film coating the small particles of entrained water. The vapor is undoubtedly the most troublesome, as it will flow along with the steam until its temperature is reduced to a point where either it, or the steam which carries it, is condensed.

Again, as this vaporized oil is carried along so easily with the current of steam, a large percentage of it must escape with the exhaust, and thus its lubricating effect is very materially lessened.

It is now easy to understand that the larger the percentage of oil vaporized when it enters the steam, the greater will be the quantity required to secure the necessary lubrication.

The cheaper grades of cylinder oils are generally composed of a mixture of mineral oil (which has not been sufficiently deprived of its most volatile constituents) with some of the animal or vegetable oils, added to increase the viscosity. These last named oils vaporize at comparatively low temperatures, and therefore are not fitted for cylinder use with the present high steam temperatures. Indeed, for every reason, cheap cylinder oils are the poorest kind of an investment.

After leaving the steam cylinder, oil may reach the boiler in several different ways: the steam may pass through a condenser, and the resulting water may pass to a hot-well, to be picked up by the pump and put into the boiler,—very common practice in marine work; the exhaust steam may be sent through a heating system, and the condensation returned to the boiler; open feed-water heaters may be used, in which the exhaust steam is sent through the entering feed water, losing at least a part of its oil, which necessarily

accompanies the feed to the boiler; or, exhaust-steam injectors may be used to feed water to the boiler, any oil in the steam entering the boiler with the water.

After entering the boiler, the oil, being much lighter than the water, floats on the surface, the minute globules coalescing so as to form an oily scum.

We have already seen that, when the dissolved salts in the boiler water are precipitated, their first tendency is to rise to the surface, and thus the oily scum, which usually occurs in isolated patches, collects these floating particles, clinging to them tenaciously until it becomes too heavy to float, and gradually sinks until it reaches a tube, a flue, or the shell, where it becomes firmly attached on account of its sticky character, and forms the most dangerous of all known scales. It is entirely impervious to water, and, as it is also a very bad conductor of heat, it allows the metal beneath to become overheated, even to redness, and a bulge, pocket, or rupture occurs. In the case of flue boilers, a collapsed flue generally follows such a deposit of oil, while, in the case of fire-box boilers, it is by no means rare to have the crown sheet "come down."

The floating patches of oil in boilers may vary in size from the area of a small coin up to nearly the whole water surface. On account of the resemblance, some have termed these sinking patches "oil pancakes."

These oily deposits are not always found on the top of flues or tubes; they also occur on the bottom and sides, the place of deposit being determined by the position of the patch before deposit. If it is rising on the surface of the water, it is apt to be deposited on the bottom, while, if falling, the reverse will be the case.

The appearance of this oil scale varies considerably. Sometimes it has a mud-like consistency, varying from a light grey or fawn color to a brown, or even black. Most of these scales have a soft, springy consistency; and this is especially true of another form of oil scale, very leathery or "soft-rubber like" in appearance and feeling.

This last is the most dangerous of all oil scales. After lying for a while in close contact with the hot sheet, gases are generated which will inflate the original deposit (which may be less than one thirty-second of an inch thick) to several times that thickness, and the new porous scale thus formed is even a worse conductor of heat than the original one. The sheet beneath such scale becomes red-hot, and then, being unable to withstand the pressure of the steam, it bulges or blows out like a soap-bubble, and finally rupture takes place. In the meantime, the great heat beneath this oil scale burns out the organic mat-

ter, and in consequence subsequent examination shows only a comparatively harmless scale.

There is a most erroneous opinion that marine boilers are much better adapted than any other form for oily feed water. The reason why they give less trouble from oil is simply that the water in them is generally more or less salt (due to leaky condensers if to no other cause), and the superior densityof the water prevents the oily scale from settling.

Great care must be observed in blowing off boilers containing oil. If the bottom blow is used, the floating oil must descend as the water is lowered, and thus become attached to the boiler surfaces. This has occurred, and the result has been, almost invariably, that the parts covered by this oil deposit have become overheated, and a general collapse of the boiler has followed. All boilers supplied with oily feed water should be provided with a surface blow, and this invariably should be opened by first causing the scum of oil to collect on the surface of the water; after this, the lower blow-off cock can be opened with safety.

On account of the ruinous effect of the oil, engineers' attention and ingenuity have been taxed to the utmost to produce some method or device for effectually removing it from the exhaust steam or from the feed water. If the lubricant used in the cylinder were either an animal or vegetable oil, the water in the hot well might be treated with potash or soda, which would saponify the oil, and the resulting curd might be removed by mechanical means; but, unfortunately, this treatment is seldom applicable, as the base of most cylinder oils is mineral oil, which cannot be saponified. It is, therefore, necessary to resort to some mechanical process applied directly to the oily water. Two methods of treatment are in general use,—skimming and filtration.

In the concluding article on this subject, which will appear next month, various devices for effecting this purpose will be described and illustrated, in connection with the general exposition of apparatus successfully applied to the removal of the direct and indirect scale-making impurities in feed-waters.

THE ARCHITECTURE OF AMERICAN COUNTRY HOMES.

By H. Neill Wilson.

EVERYTHING in nature seeks in its environment the shelter or home that is individually its own. From the snail carrying her habitation upon her back to the fowls of the air; from the mole and rabbits burrowing under the earth to the larger animals seeking their lairs in mountain fastnesses,—the creature is led by instinct to find for itself an abiding-place, and to build or select that shelter which is adapted to the needs of the life to be lived therein.

Only man, the highest form of animal life, has, from age to age, changed the form of his habitation, and it is curious to note, in reviewing the past, the evolution of the home. Progress in every form has pushed us from the rude shelter of tents and boughs, log cabins, and huts of mud and wood, to the lofty buildings that to-day tower in the metropolis and fill many of us with apprehension as we gaze upward, optical illusion leading us to see them apparently swaying in space, threatening death and destruction to all beneath.

IN BERKSHIRE. RESIDENCE OF E. POPE SAMPSON, PITTSFIELD.

HALL AND DRAWING ROOM, L. F. BECKWITH'S RESIDENCE, STOCKBRIDGE.

PITTSFIELD, MASS. HOME OF GEORGE H. LAFLIN.

It has been left to America to illustrate in domestic architecture, in infinite variety, the uses of wood in house-building. One of the first impressions made upon a foreigner is this multiformity in the wooden construction of the dwelling-houses of America. Nearly every

CHARLES ASTOR BRISTED'S RESIDENCE.

NORTH ADAMS, MASS. RESIDENCE OF A. C. HOUGHTON.

order of architecture has been reproduced in wood, to the bewilderment of men who have studied their profession in countries where stone and brick are universally used in building.

America, if it did not inaugurate, may be said at least to have amply exemplified the wooden age in architecture. Criticism in regard

LENOX, MASS. RESIDENCE OF DAVID WOLFE BISHOP.

to this prevailing use of wood varies with the nationality of the critic. If he be English or Scotch, he is appalled by the apparent lack of stability. The Frenchman is amused at the ornate nature of the ambitious reproductions in wood of that which, he conceives, should be built only in stone. Germany is more lenient toward American peculiarities, owing to having long been well-versed in the adaptability of wood in architecture, and also owing to the German temperament, which is endowed with a commendable degree of toleration and a great spirit of criticism, the result of which is seldom given unsought.

The reign of wood, however, is gradually being superseded, even

"THE HOMESTEAD," FORMER RESIDENCE OF A. P. STOKES, LENOX, MASS.

in the United States, and the stone age in architecture is advancing with remarkable celerity. In the not far distant future the new continent may even gratify that most severe critic, Mr. Ruskin, and boast of, and luxuriate in, its ruins! Should fire, storm, or earthquake visit Biltmore to-day, the much-admired result would be obtained, and time, which moulds and softens every outline, would soon produce the imperfect, and consequently the picturesque, which Mr. Hopkinson Smith declares so necessary to the landscape. "It is only," says he, "when the hand of man smirches the face of nature that we really find the picturesque."

Probably no locality is more famed for its summer or country homes

DINING ROOM, RESIDENCE OF CHARLES ASTOR BRISTED.

"SHADOW BROOK," THE ANSON PHELPS STOKES PLACE, LENOX, MASS.

THE SOUTH FRONT OF "SHADOW BROOK," LENOX, MASS.

than Berkshire county, Massachusetts, and a few illustrations will show, better than the most extended critical comment, what study and thought have been expended and what results accomplished. Lenox, Stockbridge, Great Barrington, Williamstown, Pittsfield, and Dalton are represented; yet there are so many others that are worthy that one must resort to that very charming and healthful recreation and go a-coaching or a-wheeling through the Berkshires to obtain an adequate idea of its beautiful and charming country homes.

The best illustrations of the Colonial American style in Lenox are the Appleton and the Frelinghuisen houses; these are so complete and satisfactory that one hardly notices the superb surroundings, but sees only the beautiful in the buildings themselves,—an unconscious and silent tribute to the skill and refinement that produced them.

RESIDENCE OF H. H. COOK, LENOX, MASS.

Another notable house is the H. H. Cook house in Lenox; while one associates this style with a situation upon the border of a lake protected from the violence of winter-storms, and expects the accompaniment of forests and beautiful reflections and sounds of rippling water, the grand view here secured from the higher grounds almost compensates for the absence of other charms.

"Shadow Brook," the summer residence of Anson Phelps Stokes, is probably the most extensive of the many large houses in the Berkshires. This house, built of stone, timber, cement, and tile, situated on the hillside, with the forest of grand old chestnut trees rising be-

HOUSE OF C. M. SMITH, WILLIAMSTOWN, MASS.

A PART OF THE H. H. COOK RESIDENCE.

HALL IN "THE HOMESTEAD."

HALL IN ANSON PHELPS STOKES'S RESIDENCE.

BALL ROOM IN "THE HOMESTEAD."

OAK HALL IN "SHADOW BROOK."

hind it, and overlooking the valley and lake below, and with superb views from all its many rooms, suggests the Old English, which was built by generation after generation with but little regard for what had gone before. The color of the timber-work is a soft brown that is very attractive; the effect was secured by burning the entire exposed surface, leaving the brown and black the natural fire colors.

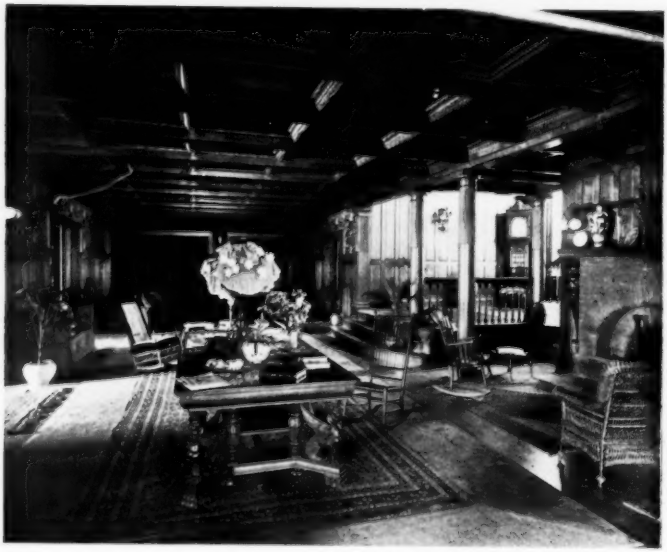
Elm Court is an example of note; it is situated on high ground, between Laurel and Mackenack lakes, commanding as fine a view as any in the region, and is built of white marble and wood. "Interlakes" is built upon a site similar to that of Elm Court, and has the

PITTSFIELD, MASS. HOME OF HENRY W. BISHOP.

same grand view. The residences of Henry W. Bishop and Mr. W. A. Whittlesey, of Pittsfield, are illustrations of village and town houses that are well known,—the former being entirely of wood, the latter of brown stone and wood.

The illustration of the billiard-room is from Blythewood, on Lake Onota, the country house of Mr. Wirt D. Walker, which surpasses perhaps any country seat in this region in beauty of views and surroundings as well as in area. This house is a curious combination of three old buildings, the center of which is conceded to be the oldest house in Pittsfield; from it many interesting old relics were secured and worked over. The house of Hon. Zenas Crane, of Dalton, is a

AN INTERIOR IN THE WHITTLESEY HOUSE.



HALL, W. A. WHITTLESEY'S RESIDENCE, PITTSFIELD.

THE BLYTHEWOOD BILLIARD-ROOM; RESIDENCE OF WIRT D. WALKER.

most interesting one from its situation on the low land, with its streams, lakes, and old trees, and a background of mountains and forest, presenting a most attractive and hospitable appearance.

The illustrations from Williamstown are sufficient to show that the same character and styles pervade the entire region. The Smith house (p. 254.) is in Colonial of the New England type, and distinctly different from the other buildings illustrated. The Procter house, built within

RESIDENCE OF HON. ZENAS CRANE, DALTON.

RESIDENCE OF H. T. PROCTER, WILLIAMSTOWN, MASS.

a year or two, is another example of the Colonial style; while denied the grand and extensive views of Lenox and Stockbridge, it has a beautiful location in the heart of one of the loveliest villages in the country.

W. A. WHITTLESEY'S HOUSE, PITTSFIELD, MASS.

Probably there is no more encouraging sign, in these times of advancement and prosperity, than the desire for information upon, and understanding of, the arts and sciences, and the study devoted to them. Many people are to-day interested in, and laboring for the institutions that help toward better things. In the United States, museums, libraries, and galleries are slowly but continually growing, and the advancement is just as surely being developed to the welfare of all. The results of this great movement are seen on all sides, and what is more natural and logical than that those so active and instrumental in creating and in maintaining these beautiful influences should themselves dwell in houses that are examples of cultivation and refinement? When one reads the criticisms on public and commercial, and on ecclesiastical, designs and results, and recognizes their justice and force, the task of writing upon domestic architecture becomes a difficult and hazardous one. For, if a home expressing the sentiment, taste, and refinement of its inmates be not beyond the intrusion of the critic and scoffer, where may we look for seclusion, freedom, and relaxation? The difficulties surrounding the designer of a country house are so numerous and insinuating, and so hard to overcome, that many good things are harmed, and the best intentions diverted through sheer discouragement. A design in harmony with the surroundings, and in some degree adapted to the needs and requirements of the occupants, is submitted to the criticism of friends and relatives, "who have had great experience in building," and then the mischief begins to develop. Their suggestions, made in all sincerity and honesty, yet without understanding the situation or object of the design, frequently destroy the scheme of the architect, and the whole is ruined from his point of view, and the spirit departeth from the house. When the architect receives the degree of confidence and reliance shown the legal or the medical adviser, "then shall his sins be upon him." But, so long as "*we* made the plans ourselves, and only got Mr. Blank to draw them out," then should their sins be upon them. One of the first inquiries made when a client explains his wants is: What style or character of a house do you wish? Colonial is popular and frequently desired, and naturally the question arises; What is Colonial? Is it an effort to repeat from memory and without skilled or professional assistance the Continental or Adams Brothers style, as so many examples in the southern States, and the old manor houses of the northern, would indicate, or is it the low-hipped and gabled style of New England, so attractive in its simplicity and quiet? And here is an opportunity to say a few words upon this problem of the owner's right to build as seemeth best to him and for his own pleasure and comfort, rather than to satisfy the critic or tourist who chances that

way. Whom should the architect and landscape-gardener first consider? Whom please? and why? Will someone more enlightened give the answer, and thus relieve the minds of many now laboring under the weight of uncertainty and doubt? Another not unusual experience is that the needs and requirements of a family change frequently and radically, and what was at one time the ideal for comfort, convenience, and utility becomes insufficient for the needs of the household. This may lead to disappointment and to criticism; but who may see and provide against such emergencies?

Some difficulties are encountered in Berkshire that are not met with in the southern or coast climates, and, after experience, the architect learns to discard many of the features that are so attractive in less severe regions. The middle south, about the vicinity of Cincinnati and St. Louis and similarly-situated cities, for instance, permits of treatment that is entirely unsatisfactory in Berkshire, and still greater liberty may be indulged in the cities of Savannah and Charleston, and locations corresponding to them in environment and climate.

The north-west, on the other hand,—Minneapolis and St. Paul being typical examples, — is more like Berkshire than any other section in its climatic conditions. The severe cold, and the curious and damaging results produced by the formation of ice on the shady portions of the roof while the snow melts on its sunny slopes, have taught house-owners and architects many lessons that are not readily forgotten. Yet who, having lived in Berkshire long enough to enjoy her people and her hospitality, has been quite satisfied to leave it? It seems a country so full of beauty, strength, and nobility in her landscape that one wonders how any one can live in it and not be generous, strong and true. Nowhere can be seen so many exponents of different styles of architecture, and some, no doubt, deserve severe architectural criticism. But, thanks to the wondrous hills and forests, every outline softens into an effect that gratifies the eye, even while it may sometimes offend the taste of the witness of truth in art. Truly, Berkshire, with her inspiration to elevate the standard of the homes of America, need not be ashamed of the results thus far accomplished, and happy is the man called by his profession to add his conception of truth and beauty to its charm, and happier still he who may own, be it a castle or cottage, a home in Berkshire.

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* The Homestead was originally built for Miss Julia Appleton, from drawings by McKim, Mead and White. The front and hall are from their designs. Mr. Wilson added the ball room for Mr. Stokes. The Cook house is by Peabody & Stearns, of Boston; the Laflin and H. W. Bishop houses by Henry Ives Cobb, of Chicago; the Sampson house by Fuller & Wheeler, of Albany; the Procter House by Mr. Stickney of Providence, R. I.; the other houses illustrated are from Mr. Wilson's own designs.

THE PRINCIPLES AND DEVELOPMENT OF THE ROTARY ENGINE.

By Elmer S. Farwell.

INTEREST has revived recently in the war periodically waged against that piece of primitive mechanism, suggestive of barbaric ignorance, the reciprocating engine of Watt. Occasionally an article appears which recites the extravagant use of energy of the present steam engine, and gives assurance that, with some forthcoming invention, the largest ocean greyhound can be run across the Atlantic with the energy contained in a pint of water, provided no one on board is skeptical or out of sympathy with the new motor. Such a statement is at once recognized as an old acquaintance. It is also tame news that the steam engine is to be supplanted by the electric motor deriving its energy from some unknown source.

The latest canard, however, at least is garbed in new attire. It emanates from a little town bearing the significant title of Sleepyeye, and is to the effect that the old steam engine has been completely routed. It is to be immediately forced into oblivion by a startling new invention in the shape of a steam engine which revolves, and which, Minerva-like, has sprung into full and complete existence from the head of an inventive Jupiter. For this rotary engine the "English Syndicate" so dear to the hearts of a section of the American public is said to have paid the usual fabulous price.

It is not in the province of this article to discuss whether or not the rotary engine ever will supersede the ordinary reciprocating engine, either in whole or in part. But it may not be unprofitable to glance at the attempts heretofore made to accomplish this.

Retrace the paths of progress through the dark ages almost to the dawn of history, and there an account of a rotary steam engine will be found. It is, in fact, the first attempt to utilize steam of which any account exists, either in history or in tradition. Known to the earlier ages of Egyptian science and to the later ages of Grecian refinement, this engine appears to have played its part in adding to the elegance of oriental luxury and to the mystification of idol-worshippers.

It is possible that, had not the magnificent Alexandrian library been destroyed by the Mussulman zealots, other records of a similar nature would now exist. Both Pliny and Vitruvius mention Ktesibios as famous for his skill in the invention of pneumatic and hydraulic in-

struments, and refer to the Commentaries of Ktesibios himself. These Commentaries are lost, but Hero, a pupil of Ktesibios, in a work on pneumatics,* published about B. C. 150, has preserved many inventions of those who at that time were "ancient philosophers and mechanicians." He says in his introduction: "We have thought proper to arrange in order what has been handed down by former writers, and to add thereto our own discoveries,—a task from which much advantage will result to those who shall hereafter devote themselves to the study of mathematics."

The fiftieth proposition of this remarkable work presents the embryonic steam engine. A closed boiler supports above it a hollow ball, which communicates with the boiler through a hollow support. Attached to this ball are two bent tubes, through which steam issues, causing the ball to revolve in the opposite direction by its reactive force. The uses of this engine were various, and its possibilities great. No one can guess at this late day what hazy visions floated over the mind of this ancient engineer, as he "arranged in order" this beginning of the greatest civilizing art. It contains the germ which, had it been industriously nurtured, would have developed into a nineteenth-century motor. But its inventor was about two thousand years in advance of his times. The Alexandrian engineers were content to raise water by hand, and drag their immense burdens over the sands with thousands of slaves.

Following this, there was practically nothing done toward utilizing the energy of steam for sixteen centuries. In the awakening after the dark ages attention was directed anew to the subject, and a few attempts were made to solve the problem.

One of the earliest of these attempts was that of the Italian engineer, Giovanni Branca, in 1629. In his engine a jet of steam impinged upon the vanes of a horizontal wheel, communicating through a series of toothed wheels with a shaft, from which power was to be taken for many useful purposes. This also was soon forgotten.

From this time on the application of steam to the production of rotary motion seems to have been entirely neglected. All attention and interest were now absorbed in the practical problem of raising water. So important to the Britons had this problem become that all others were obscured. Their mines were being flooded, and would have to be abandoned unless the problem should be soon solved economically. The natural product of this condition was the reciprocating engine of Newcomen. This is the engine which Watt found and applied to the rotation of a shaft. Great as was this step, and great as has been the resulting progress, it does not necessarily follow that

* "Pneumatics" of Hero, translated by Woodcroft: London, Taylor, Walton & Moberly.

it was the only, or even the best, solution of the problem. If an engine could be devised which would economically produce rotation direct without the intervention of the complicated mechanism of the ordinary engine, it would certainly be a great advance. Watt recognized this, and set out to accomplish it. In his first patent, granted in 1769, he suggested a "rotatory" engine in which the steam vessels or cylinders are in the form of hollow rings, or circular channels, and are attached to the shaft which they rotate. Later, he actually constructed a "rotative" engine, for which he received a patent in 1782. But even in this engine the dominant idea of a piston and reciprocating part is retained. Rigidly attached to the shaft is a piston which moves in a cylindrical vessel. An abutment is hinged to the outer part of the casement, to allow the piston to pass and rotate continuously in one direction. Some modifications in detail were suggested. After many attempts and failures, he wrote: "they have their respective merits; but instead of being more simple in their construction, they are more complex than those derived from reciprocating motions, and more difficult in execution." These conclusions have since been verified by a great many inventors of this type of engine.

In these first three rotary engines are illustrated the three general types,—the reaction engine of Hero, the impulse engine of Branca, and the piston, or pressure, engine of Watt. Each of these pioneer inventors has had many followers, as the records of the patent office will show. Most, but not all, of these engines have existed only on paper, or in the fertile imagination of the inventor. In some instances the engine has been built, and proved the first and the last of its species.

A glance at an ordinary engine, with its piston, crosshead, wrist pin, crank pin, eccentric, and distributing valves, all consuming power, and with its massive frame to withstand shocks, heavy fly-wheel, and costly foundation, shows at once that it is not an ideal motor. The idea of a rotary engine dispensing with all these complications at once presents itself. The problem seems so simple, fascinating, and easy of solution as to have induced many to attempt it. But at present the ordinary engine appears to be very much in evidence. The contemplation of a light, simple, compact engine running quietly at a high speed, with no dead center, the pull absolutely uniform, no fly-wheel, and on practically no foundation, is truly an alluring dream.

The lack of originality displayed by the majority of these inventors is very marked. They have done what at first thought seemed so simple,—*i. e.*, attached the piston directly to the crank, and let it rotate in an annular cylinder. They have dispensed with some of the objectionable features of the ordinary engine, but retained and usually

aggravated the worst one. The piston must still be packed and lubricated, so that the same difficulties exist in the use of high-pressure or superheated steam. As the action of the steam is the same as in an ordinary engine, no more of its intrinsic energy can be utilized, and the cylinder is still subjected to alternate heating and cooling. The difficulty of making a rectangular piston to fit the cylinder so tightly as to avoid an extravagant leakage of steam is not easily overcome. If it is made steam-tight, the friction is out of all proportion to the size of the engine, since the piston-speed is so high.

Many engines of this type have been made by eminent engineering firms, but have never been able to compete with the ordinary engine where any consideration is given to the question of steam economy. Some fifty years ago two vessels were fitted with engines of this type, made in accordance with the patents of Peter Borrie. Both boats were lost at sea, and the experiment was never repeated.

Mr. Westinghouse attempted to solve this problem of friction by using for the cylinder a bushing which was free to revolve with the pistons. Steam-packing grooves were employed between the bushing and cylinder. The friction of this bushing on the cylinder was said to be but one-twentieth of what would have been developed with no bushing under a similar condition and velocity of piston.

Fully eighty-five per cent. of the rotary engines heretofore patented have been of the piston type, and not one of them, it is believed, was ever in successful operation.

The reaction engine of Hero is the simplest possible form of steam engine, and, where fuel economy is of little moment, it has been "successfully" employed. Its success apparently lies in the single fact that it runs.

About the year 1833 Mr. Avery built several engines of this type, one of which was used for several years to run the machinery in his shop. Another was employed to drive the printing-presses of the *American Railroad Journal*. The editor of this paper records that "it is indeed so perfect, and the velocity so great, being about five thousand revolutions per minute, that, but for other machinery attached to the engine, a casual observer would scarcely know that a steam engine was in operation." This engine was also applied to a locomotive which ran for some time on the Newark railroad,—"with great success," the enthusiastic editor states. Continuing, he says: "When Mr. Avery shall have completed another and more powerful engine, which he has now in course of construction, we doubt not his attaining a greater velocity than has ever yet been attained in this country or even in Europe. We shall probably be deemed rotary-engine mad when forty miles an hour is named as not difficult of attainment."

"This engine will, we doubt not, perform all we have here predicted; and, if so, what can prevent them from being generally adopted on all our railroads?" But it does not appear to have been very generally adopted. At least a large percentage of the locomotives of to-day still cling to the reciprocating principle. Possibly Mr. Avery was unfortunate in living at a time when the "English Syndicate" was unknown in America. But, "with true Yankee enterprise," he took one of his engines, complete, to England. "If the mountain will not come to Mahomet, Mahomet will go to the mountain." Although this appears to close the history of this interesting engine, it is to be hoped that it did not prove a Jonah, as did that of Peter Borrie.

Recently Mr. Morton has been experimenting on this type of engine. He has adopted a peculiarly-curved and expanding nozzle, and uses two or more discs in series. He obtained fairly good results, but not such as to warrant their general adoption.

In this type of engine many of the objectionable features retained in the rotary-piston engine have been disposed of. There are no moving parts to be packed; consequently there is no friction, except on the shaft. The steam comes in contact with no lubricated surfaces, thus permitting the use of high-pressure superheated steam. There is no oil in the exhaust steam to cause priming in the boiler, and priming, if it should occur, cannot ruin the engine. With a properly-shaped nozzle, an efficient expansion of steam may be had without alternately heating and cooling any surface.

A moment's consideration, however, of the theory of reaction wheels will demonstrate the fallacy of their use. Their efficiency cannot reach unity until the wheel revolves with a peripheral velocity equal to the velocity of efflux of the steam—a practical impossibility. Should the velocities thus become equal, the work which might be performed would become zero. No economical performance, therefore, can be expected from this type of engine.

The impulse engine of Branca alone remains to be considered. Mr. Dow and Mr. Parsons are both building engines of this type. Both engines operate very much on the same principle as the hydraulic turbine. The steam passes through a set of fixed guides, and impinges on moving vanes. After giving up part of its energy here, it passes through another set of guides, and impinges on another set of moving vanes. This is repeated as many times as is desirable, according to the size, power, and speed of the engine. Very good results are said to have been obtained. They have all the advantages of the reaction engines, together with some additional ones. But, as the clearance between the moving vanes and fixed guides is appreciable, it would seem that the leakage must be considerable, and

the steam consumption consequently high. Besides, there is no way of regulating them, except by a throttle governor. Notwithstanding these apparent objections, Mr. Parsons has succeeded in introducing a number of his engines for use in electric-lighting plants. The perfect steadiness of motion of this engine, running at about five thousand revolutions, is said to prolong the life of an incandescent lamp materially.

M. de Laval has attempted to solve the question of leakage of steam by allowing the steam to completely expand in a properly-shaped nozzle, and convert its entire energy into actual energy before striking the revolving blades. As there is but one set of blades, the speed is necessarily from twenty-five to thirty thousand revolutions per minute. Much power is lost in the high-ratio reduction gearing. At this high speed the disc assumes its own center of rotation, which may not, and usually does not, coincide with its geometrical center. A flexible shaft, therefore, has been found necessary. This engine also is governed by throttling. No provision is made in any of these engines to renew the parts worn by the action of steam, and by that of "grit" which comes over with the steam, and a slight deformation of the nozzle or blades reduces the efficiency materially. This engine is meeting with some favor, particularly in France. Authentic tests place the steam consumption low.

Mr. Curtis has recently attempted some improvements on this engine by providing a better regulation, and reducing the speed. He provides means for varying the size of the nozzle, but at the sacrifice of its proper shape. For complete and economical expansion of steam the nozzle should be circular in cross-section and gradually expanding. In order to reduce the speed, he allows the steam to impinge on a series of blades in succession. As the steam is completely expanded in the nozzle, there is not the tendency to leakage that exists where the steam is constantly under pressure. Recent preliminary tests of this engine show that, when operated non-condensing, the steam consumption is about equal to that of a non-condensing high-speed simple reciprocating engine, and, when operated condensing, the steam consumption is about seven per cent. more than that of a compound condensing reciprocating engine.

On the whole, it is safe to say that, whatever the advantages of the ideal rotary engine, and whatever the future may have in store, the days of the reciprocating engine are not at present easily numbered. However, the indications are that the rotary engine has come to stay, and may soon find a place in the arts peculiarly its own. It is interesting to note, also, that the type which now gives the greatest promise of success is the second oldest known.

REVIEW OF THE ENGINEERING PRESS

Efficiency of Built-up Wooden Beams.

BOTH to engineers and architects the subject named in the above title is of growing importance, in view of the rapidly-diminishing timber resources of the United States. Already difficulty in obtaining beams of large size is experienced, and resort to built-up beams will become more frequent as time goes on. Prof. Edgar Kidwell, in *Engineering News* (March 11), refers to the meager literature of the subject, consisting for the most part of data supplied by Tredgold and freely copied without question by other writers. The majority of these, in cautioning against the belief that a built-up beam can be made stronger than a solid one of the same timber and dimensions, leave it by implication to be inferred that such beams may be made at least as strong as solid beams,—a conclusion which, Prof. Kidwell affirms, is not warranted by his own practical experience. He has therefore made the strength of built-up beams the subject of experimental tests, and promises to publish later a full report of the data so obtained. In his contribution to *Engineering News* he anticipates this report by a brief summary of results, defining efficiency as "the ratio of strength of a built beam" to the strength "of a solid one of the same size and quality of material." The method of the tests is given as follows: "Best quality clear white pine was used, and each piece was sawed into four equal sticks by one longitudinal, and one middle cut. Of these, two pieces diagonally situated . . . were made up into a compound beam," while the other two "were tested as check pieces." The sum of the breaking loads of the two check pieces was doubled, and to this was added the weight of the two pieces. The result gives four times the average strength of a check piece, which is equivalent to the strength of a solid beam double the depth of the check piece, and of exactly the same quality. The breaking load of the built beam, corrected for weight, was then divided by the quantity just found, and the result was the efficiency. Up to date seventy-four built beams have been tested. Clark's design for built beams is criticised as not based on correct principles, and as lacking both in efficiency and stiffness. The efficiency stated by Clark is also challenged on the ground of an error in reasoning. Keyed or joggled beams are considered superior to any other form. The average efficiency of all the built beams so far tested by Prof. Kidwell is 87.7 per cent., the lowest efficiency being 55.5 per cent., and the highest being 108.5 per cent.,—a solitary instance wherein a figure higher than that of the solid beam is tabulated. Whether this exceptional percentage actually existed, or is a misprint, or is the result of a defective experiment, seems uncertain. It is hardly conceivable that an efficiency greater than that of a solid beam could have actually existed. Many useful hints relating to the building up of beams, and to the movement of the keys and other fastenings due to the yielding of the wood, are presented in Prof. Kidwell's article.

English Homes for Workingmen.

THE above is the title of an illustrated article contributed to *The Inland Architect and News Record* for March, by Octavius Grant Wood. It describes Port Sunlight, a model village for working people, situated less than six miles from the steamship landing at Liverpool. The problem of supplying comfortable sanitary dwellings for working people has had many of its difficulties removed by the introduction and great extension of cheap suburban transportation. The village of Port Sunlight well exemplifies the possibilities in suburban dwellings erected where land is comparatively cheap, though, as the dwellings therein are occupied mainly by workmen employed in a manufacturing industry conducted there, the working out of the solution has not been complicated with

the problem of transportation, as would have been the case had the inhabitants been employed in the adjacent city. No one who peruses Mr. Wood's description will dissent from his view that "this village is worthy of the attention of all students of political economy and social science, as showing by actual practical demonstration how much can be done to bring about happiness and plenty to all employed there." The industry, we are told, has prospered under this liberal policy to the workmen, but some additional information concerning its nature, the wages paid, etc., would have been acceptable, and is desirable. The village is young, having been founded a little over ten years ago. "The streets are laid out after the style of our American cities somewhat, with trees planted in the streets and lawns in front of the houses. It is not modern in the sense of some of our American towns, with electric cars rushing through the streets, and saloons on every corner; there are no aldermen to give away franchises regardless of the will of the people; but the homes of the workmen are modern, and contain the luxuries of bath, hot and cold water, gas, water-closet, etc.,—in fact, all scientific sanitary arrangements. Cosy fireplaces are in nearly every room, and all are neatly decorated." All this is afforded for a monthly rental of from four to six dollars. The rent includes gas and water, and "is scarcely sufficient to keep the houses in repair." It is evident, therefore, that houses of this kind could not be rented at such rates to people not employed in the industry which supports the town, and that the difference between the stated rentals and such rentals as would pay, over and above repairs, a fair interest on the investment must be regarded as part of the wages of those who reside in them. The employer and employed together govern the village. There are some twenty departments in the works, and each elects from one to six members of a "village council," the manager of each department being also a representative therein. The village appears to be remarkable for its clubs and social institutions. In fact, Mr. Wood tells us, "the main work of the council appears to be the management and care of these clubs and social institutions. . . . To be a member of any club or society costs twenty-four cents a year, the firm adding three times this amount for each person joining, and supplying billiard tables, music, musical instruments, band uniforms, etc." Here, therefore, is another item in the wages of the employees. There are public buildings, including a large hall; a pavilion for club meetings; brick school buildings, costing $70,000, finished with English oak, and supplied with school furniture made in the United States; and a church which "dates back to the time of Cromwell, and was only saved from destruction by that great reformer turning it into a stable for cavalry." The schools are free, being maintained by the employing firm (Lever Brothers). Here is still another wage item. The homes of the workingmen are, however, the great feature of interest to architects. Think of the dwelling of the immortal Shakespeare, at Stratford on Avon, having been adopted as a model for workingmen's homes, the interior having been "modernized and arranged for family comfort." This has been done, however, "and the workman returning home after his eight hours' work, to one of these beautiful cottages, all clean and neat, may be just as happy as the prince returning from the chase to his castle. . . . There is a total absence of all signs . . . that the place does not belong to the employee as well as the employer; and whether it is socialism, collectivism, communism, profit-sharing, or simply good, sound business management, the fact is plain to all that prosperity and good wages, short work-day, and all manner of pleasures are to be found in Port Sunlight."

Curious Freak of a Voltaic Arc.

WESTERN ELECTRICIAN (March 27) describes the curious behavior of an electric arc, its cause and its remedy. The arc was used in connection with a hemispherical reflector to illuminate an advertising device, one of the carbons being slightly below, and the other substantially above,

the axis of the reflector. The reflector was set at such a distance from the point of ignition of the lower carbon that, when the upper carbon was ignited, the heat from it was concentrated directly upon the lower carbon. When the latter carbon burned away, which it did so rapidly as to almost extinguish the light in about half an hour from the time of lighting, the lamp adjusted itself to a position that focussed the heat from the reflector upon the upper carbon, which then burned away in about the same time as the lower one did. Considerable annoyance was experienced before the discovery of the cause led to the proper remedy,—the substitution of a parabolic reflector for the hemispherical one. Previous attempts to cure the trouble by changes of voltage and amperage failed to produce the desired effect, because the curious action of the carbons depended upon a cause entirely independent of the current,—the concentration of heat upon the carbons by the hemispherical reflector. The latter cause would probably have suggested itself at once to a tinman of forty years ago; for, when the old tin wall candle-sticks were used with tin reflectors placed so as to improperly focus the heat upon the candle, the candle was sure to melt away till too short to receive the intense heat-reflection at the focus.

Hot-Water Heating without Fuel.

SUCH is the kind of hot-water heating, according to *The Metal Worker* (March 20), in use "in the vicinity of Boise, Idaho, where, in 1891, thermal waters were discovered at a depth of nearly four hundred feet." As the water, when discovered, gushed to a height of about forty feet, it is plain that it has pressure enough to raise it to the top floors of ordinary dwellings, whence it will flow down and out, and, passing through pipes and radiators, will radiate heat precisely as though this water circulated in an ordinary hot-water heating apparatus in which the water is heated artificially. In fact, it is probable that the expression "heating without fuel" is, in this case, strictly accurate, the water being heated by subterranean chemical action, which is analogous to the action of water upon quick lime; though, if we should trace the series of causes back far enough, we probably should find combustion going on somewhere in the line of approach. But, taking the matter as it now stands, there is, in the vicinity of Boise, a store of subterranean hot water which is under pressure enough to spout above the surface when tapped by artesian wells. In any place where subterranean hot water can be procured, at a depth from which it can be economically pumped through the pipe systems of houses, heat can be distributed in this way. It would make substantially no difference whether the hot water was first pumped to the top of a building for this purpose, or pumped into the bottom of a pipe system to be forced up through such a system; but the latter plan would, we think, require less water. This would introduce the hottest water into the lower part of the system, and it would get cooler as it rose to the more easily warmed upper part. Somewhat less water might thus be required, and less pumping would be needed to supply it. The water at Boise is said to have a temperature of 171° F. A company has been formed for piping the streets and supplying this hot water for heating purposes. *The Metal Worker* gives plans of the different floors and basement of a large building piped for heating in this way. It is claimed that, at the rates at which the water will be supplied, heating by this method will cost about fifty per cent. of the expense of heating with coal at five dollars per ton.

Direct Generation of Electricity from Carbon.

IN a lecture delivered by Willard E. Case before the New York Electrical Society on February 24, belief was expressed that tremendous results will be reached in a field of which we have only crossed the boundaries. This field is that of the direct generation of electricity from carbon without the intervention of the dynamo, or its equivalent. A number of thermo-cells were described and experimentally illustrated by Mr. Case in the course of the

lecture. In the most ordinary method of obtaining current electricity, these wasteful processes must be successively performed. First, heat must be generated from fuel and stored up in some expansive material,—say, steam; second, this heat (or, more properly, only a fraction of it) is converted into work,—the most wasteful process of the three; and, finally, the work so performed is converted into current electricity by a dynamo. Doubtless, in any process for directly generating electricity from a chemical reaction between carbon and oxygen or other substance found suitable, there will always be some waste; but in a well-developed process waste would, in all probability, be very much less than the total waste in the three processes named. The carbon-consuming cells of Jablochkoff, Bard, Crumm, Edison, Wright, and Thompson were briefly mentioned, and the cell invented by Mr. C. S. Bradley with the coöperation of Prof. F. B. Crocker was described more at length. This cell consisted of an iron vessel containing fused sodium manganate and carbon. When air was blown through the fused sodium manganate, nascent oxygen was presented to the carbon. These two combining, a current of electricity with an e. m. f. of one volt was obtained. The sodium manganate was formed in the cell itself by heating caustic soda and peroxid of manganese, in the containing vessel of the cell, 2½ inches in diameter and 6 inches deep. The heating was effected by a gas flame. The lecturer asserted that the cell of W. W. Jacques, which has of late been considerably discussed in the technical press, is substantially nothing more than the Bradley-Crocker cell; or, rather, it is something less, since it differs from the former in nothing except the disuse of the peroxid of manganese, employing the fused caustic soda alone. Mr. Case thinks the theory of the action of these cells is very imperfectly understood, basing this view upon the erratic character and action of both of them; and he described some curious variations in their operation under different conditions. Mr. Case exhibited a cell of his own for the direct generation of electricity by the oxidation of carbon without increase of heat above the normal temperature, and gave a good description of the same. "It consists of two electrodes, one of carbon, surrounded by powdered carbon, in a porous cup, and one of platinum, both being immersed in a glass jar about one inch in diameter and six inches in height and containing sulphuric acid." Chlorate of potash being added, peroxid of chlorine is formed, which yields its oxygen to the carbon and sets up an electric current between the electrodes, the e. m. f. being $1\frac{1}{8}$ volts, more or less, according to the conditions. Mr. Case said: "What I wish to impress upon you is this: in this battery . . . carbon is completely oxidized at normal temperature by oxygen which is held in loose combination. So it is done in the human body, and we know that to be a very efficient machine." In conclusion he expressed his entire belief that a cheap means for doing this will ultimately be found.

Education of Railroad Men.

PROBABLY few men could be found better qualified by occupation, training, experience, and observation to speak authoritatively upon this subject than Mr. Walter G. Berg, well and widely known as an able engineer, a capable railroad man, and a very acceptable contributor to technical publications devoted to engineering and railroading. In these reviews we have frequently recorded valuable opinions and suggestions publicly expressed by him. Not the least valuable of these are broad views of the need of special training for railway men, to fit them for a service which, in many of its features, more nearly approaches military service than perhaps any other civil occupation. The present deliverance printed in the proceedings of the New York Railroad Club for January of the present year, he introduced by stating that he had been "interested for a great many years in the question of the proper education of railroad men;" that twenty years ago he "prepared the data for a report on technical education abroad, embodied in one of the United States consular reports, and visited, supplied with suitable government

credentials, the principal technical and trade schools of the continent and, subsequently, of this country." He also directed attention to the fact that he had written and published an outline for a proposed school for railroad men.* He therefore asserted his views, not as crude, immature concepts, but with the positiveness of convictions long ago formed (and subsequently strengthened by personal observation and study) concerning "the conditions existing in the important business of railroading, taken as a science, a profession, and a trade." Mr. Berg's remarks were in the nature of a discussion of a valuable and suggestive paper read before the New York Railway Club on January 21, by Mr. George B. Leighton, which set forth the facts that "in the upper ranks of the service the highest professional skill has to be brought into play;" that "the railway service bears a most marked analogy to a military system;" that "railway managers are unfortunately, as a rule, forced to devote their time and strength to daily routine details, instead of being able to maintain a general oversight, to settle difficult questions, and to prescribe rules and systems to be followed,—the correct work of true generalship,—and that 'the men who decide these problems to-day have trained their minds almost wholly by experience,—a most thorough teacher, but sometimes a costly and slow one.'" Mr. Berg concedes all these facts, and also agrees with Mr. Leighton "that much . . . of the work, and most of the principles that underlie the successful operation of a railway," can be taught in schools adapted to the railway profession; and that it is desirable that the higher class of railroad work should rank as a profession in itself. But he believes that it would be a grave error to provide alone for the training of this higher grade, as seems to be the aim of Mr. Leighton. On the contrary, Mr. Berg is very positive that "the proper solution of the educational railway problem, as a whole, lies in making sharp distinctions, and maintaining strictly the divisions between the educational plans for the various grades of railroad men." He holds that "heterogeneous elements cannot be shaped in the same educational mold, and that combination systems can never meet successfully the educational requirements of all the various classes of railroad employees. In other words, any contemplated educational system should define specifically which grade of railroad men it is primarily intended for, and be strictly arranged accordingly. Then the party who has a shop mechanic in mind could not taunt the advocate of a special collegiate course with the query: 'What good is calculus, theory of government, political economy, and railway law to a shop mechanic?' while, *vice versa*, the other party, having in mind an education preparatory for entrance into the general or professional offices of a railroad, could not retort by asking: 'Why waste years of a boy's life at a lathe?' The much-vaunted and misunderstood manual-work departments of collegiate institutions would then be relegated to their proper sphere,—namely, to serve as a practical illustrative adjunct to the class-room." Therefore, dividing railroad men into three classes,—(*a*) the highly educated class, instructing and leading, (*b*) the middle class, which supervises and carries out details, and (*c*) the lower class, performing the heavy common labor,—Mr. Berg would draw the line of distinction between the high and middle classes as definitely as possible, "keeping the education of the two as separate and individual as possible," as "the first and most important step forward in the solution of the problem." By implication there are other steps to be taken, and Mr. Berg elaborates these and presents a programme for a special railroad trade school, very much too long for reprint in this place, but to which, from its nature, justice could be done only by presenting it entire.

* *Railroad Gazette*. 1887.

Decimal Wire Gage for Wire and Sheet Iron.

THERE is, no doubt, a most decided leaning towards the adoption of the decimal wire gage, on the part of the majority

of American engineers and mechanics. Such being the case, there is little doubt that a decimal gage is to be the gage of the future. An influence that retards the adoption of the system is the effort to substitute the metric unit for the inch. It is impossible to accurately express thousandths of an inch in the metric system. Hence, if the inch is to be a unit retained (we believe a large majority of engineers, mechanics, and manufacturers want it retained), the metric system, if also retained, will compel another scale of sizes, and therefore we shall be working under different systems as at present, with the same attendant inconveniences. At the request of the council of the American Institute of Mining Engineers, Mr. R. W. Raymond presented at the Chicago meeting of that body, in February, an abstract of the report of Mr. Albert Ladd Colby, of South Bethlehem, Pa., which the latter gentleman presented at the meeting of the Association of American Steel Manufacturers at its October meeting in New York. The report credits the American Institute of Mining Engineers with originating the movement for a decimal gage in 1877, a committee appointed to consider the matter having in October of that year reported favorably upon the proposed change. In 1892 the American Society of Mechanical Engineers also received a report favoring the change from a committee appointed to consider the subject. The change has also been favored by the American Master Mechanics' Association, while committees of coöperation were constituted by the Canadian Society of Civil Engineers, the Engineers' Club of Philadelphia, the Civil Engineers' Society of St. Paul, and the Engineers' Club of St. Louis. The report of the committee of the Association of Steel Manufacturers was mainly directed to the consideration of the advisability of the endorsement by the association of the United States standard gage, approved by act of congress, March 3, 1893, and it advocated the exclusion of all other gages now in use. The fact that, while the United States standard was disapproved, a decimal gage of thousandths of an inch was recommended shows very plainly the drift of opinion in the United States. The United States standard was based upon the relation of weight to the thickness of a square foot of iron rolled to a thickness of $\frac{1}{160}$ of an inch. Such a sheet of iron would weigh one ounce, estimating a cubic foot to weigh 480 pounds. The absurdity and practical inconvenience of such a basis is set forth in Mr. Colby's report in the following quotation:

"There is no practical value to this association in the simple relationship between the United States gage numbers and the weight in ounces per square foot of the sheet or plate measured: first, because when plates are ordered by weight, customers specify the weight in *pounds* per square foot, and not *ounces* (there is no simple relationship between pounds per square foot and these gage numbers . . .); and, second, because the simple relationship between ounces and gage numbers is only true when the sheet or plate is made of iron." This gage merely adds another to the long list of arbitrary gages with numbers in inverse order to thickness, and, as it is open to severe criticism in other respects for defects from which the decimal gage would be wholly free, the report is decidedly favorable to the latter and adverse to the United States gage.

American Machine-Tools—An English Criticism.

It is, in our opinion, quite possible that there is more truth than poetry in the statement of M. H. Austin, works manager of the Wolseley Sheep-Shearing Mach. Co., Limited, Birmingham, England, made in *American Machinist* (March 25). He says he has charge of about fifty thousand dollars' worth of American machine-tools, and that the term "manufacturing" rather than "building," as these terms are used in England, is most applicable to the production of the American tools sent to England, judged by the samples he has charge of. As we have said, this may be the truth. Fifty thousand dollars' worth of machine-tools is not a large fraction of the entire American output. It would not be considered even a large order by many

of our machine-tool builders. If the purchaser of these tools desired to obtain them at the lowest possible price, he could easily have got such tools as are complained of. Builders of inferior tools are to be found in America; possibly some could also be found in England. It is, we submit, hardly fair to judge the entire output of American tools from the small fraction named, unless it can also be shown that they were selected from the tools of representative American builders. We are the more inclined to the belief that the machines complained of are not the product of our best establishments from the statement of the defects made by this English critic. The drills are stated to have their bases and, in some cases, their tables out of square with their spindles, and to have "too light, unsupported columns." True, he says further on that among these tools there are American lathes, "*some of all the best makes*," not one of which bores a parallel hole; but here we do not know what or who the critic has in mind when he says best makes. If he intends to assert that no lathes are made in the United States that will bore a parallel hole, or that have their spindles in line with their beds, within the limits of accuracy possible to the most accomplished English mechanics, he knows little or nothing of the "best makes" of American machine-tools. The rule laid *down* by this critic with reference to testing machine-tools before they are sent out from the works for sale is a good one. He is correct in saying that "no system of manufacture, however elaborate, is of any use without this precaution, at least," if complete satisfaction is aimed at.

Refined Measuring of Bridge Strains.

THE record of the progress of science is more an account of improvement in and performance of refined and accurate measurement than anything else. In proportion as mankind has learned how to measure and weigh, not merely the grossness of matter, but the thrusts, stresses, attractions, and repulsions of invisible forces, has the human race acquired a broader and more complete mastery of the potentialities of nature. Chemistry was nothing, till the balance became its most important aid. Astronomy is, *par excellence*, a science of refined measurement. Civil engineering is based wholly upon data obtained experimentally, upon formulæ derived from the mathematical analysis of such data, and upon refined measurement in surveying, triangulating, levelling, and grading. *Scientific American Supplement* (March 20) notes a number of instruments whereby very delicate determinations can be made,—among them a new instrument which measures so accurately a small fraction of the total strain, say, of a structure like the great suspension bridge connecting New York and Brooklyn, that the increase of strain due to the step of a foot-passenger on that great mass of metal would, it is claimed, be instantly and correctly indicated by it when used with proper precautions against certain errors to which it is liable in the hands of an unskilled manipulator. The instrument embodies a principle which has been much used in delicate measurements—to wit, the change of the direction of a reflected beam of light by a slight change in the position of a small mirror. The reflecting galvanometer of Lord Kelvin, according to Prof. Sylvanus P. Thompson, is capable of indicating to an audience of a thousand persons an electric current of one fifty-four-thousand-millionth part of one ampere, when a lime light is employed. The new instrument, designed to test the expansion and stretching of metals under heat or strain, is described as being very simple. "Its chief part consists of a couple of little mirrors carried on spindles, which, in turn, are fastened to a couple of knife-edges, so that the slightest change in the position of the knife-edge causes a deflection of the mirrors. For the rest there is an ordinary reading telescope, to which is attached a finely-graduated scale, reading down to a hundred-thousandth of an inch. These readings cannot, of course, be detected with the naked eye, but only through a strong telescope. Now, when the knife-edges are lightly clamped against the object to be tested, say, a bar of steel, and the latter be stretched or

expanded, the knife-edges will change position, the mirrors will be deflected, and, as the latter is looked at through the telescope from a distance of five or ten feet, the graduated scale which the mirror reflects seems to move up or down." Of course, the amplitude of this apparent movement supplies the needed datum for calculating the extent of the stretching or expansion. This being the case, great care must be taken to prevent the vitiation of tests by even very minute variations in temperature. On account of its sensitiveness to temperature, it seems hardly possible that, as our contemporary seems to intimate, the instrument could ever be of service in out-of-door determinations of variations of strains in bridge structures and the like, however much it may be adapted to refined researches in the laboratory.

Resistance of Ships at Deep and Shallow Draft.

THE literature of this subject is probably more extensive than that of any other connected with marine engineering. Mr. Joseph R. Oldham, in a paper read before the Civil Engineers' Club of Cleveland (*Journal of the Association of Engineering Societies* for February), says that it would be "a formidable task to merely enumerate the names of eminent mathematicians and experimentalists who have endeavored to discover the laws of the resistance which water offers to the progress of ships, and still more formidable would be any attempt to describe the various theories that have been devised. Again and again has the form of least resistance been announced, but none of these has largely influenced the practical work of designing ships, nor can any be regarded as on a thoroughly scientific basis. In fact, a century and a half of almost continuous inquiry has firmly established the conviction that the problem is one that pure theory can never be expected to solve. The experimental tank for ascertaining the resistance of the wave-making qualities of ship models has proved the most valuable adjunct of the scientist in confronting the multitude of mistaken theories advanced from time to time in connection with ship resistance." It was once very generally believed that a ship's resistance was principally the result of the inertia of the water, and that skin friction was the lesser factor. Now this belief is reversed; the friction factor is the one most considered, and the element of resistance caused by the inertia is little regarded. The modern view is that the resistance which a ship encounters from the water is that generated by minute eddies against the hull, and that the velocity of these eddies is a function of the velocity of the ship and her model. "At ten knots per hour the eddy resistance is one pound per square foot of augmented surface, and varies generally for other speeds as the square of the velocity. The bow, however, always experiences resisting pressure in proportion to the square of its velocity of motion, and requires horse power as the cube of the velocity to overcome resistance. Mr. Oldham's paper proceeds to a discussion of the effect of draft and depth of water in which a vessel moves upon her speed; he cites experimental data to show that, if the total depth of the water be too small in proportion to the draft of the vessel floating therein, a reduction of speed is a consequence. This is one of the conditions which have retarded success with self-propelling boats in shallow canals. One example is given wherein a difference of speed of half a knot over the same measured mile was found to exist between high and low tide. A proper depth of water is, therefore, an essential for a trustworthy speed trial. This question of the relation between the speed of vessels and draft and total depth, is of great importance in the construction of vessels for navigating shallow lakes, rivers, and canals.

THE BRITISH PRESS

The Mutual Relations of the Architect and the Public.

IT is interesting to note the opinions of an accomplished and experienced architect upon so broad a topic. This review is an abstract of a paper dealing with it, read by Mr. W. H. Bidlake before the Royal Institute of British Architects and printed in *The Builder* (Feb. 27). Although there is not an inherent antagonism, but quite the contrary, between the architect and the public, there is not that harmony which is desirable. Each taxpayer and rate-payer is a client where State or municipal buildings are concerned. His interest in the matter will lean toward economical construction. The British public is charged with indifference to architectural matters, and it is to the credit of British architects that, notwithstanding this fact, so much good architectural work is done. In the time of Seti or Rameses the services of the architect were counted among the highest in the State. The architect was held in similar regard in ancient Athens, and in Florence in the days of the Renaissance. Some of the architects of that period achieved immortal fame. While "a certain degree of wealth ungrudgingly spent is necessary before the enthusiasm of a people can express itself in grand architecture," a too "easy commercial prosperity" begets "a content with the uneventful, commonplace present." Under such a condition, instead of longing and idealizing, people seek luxury and social position; but, "when a people is touched in its heart and emotions, especially when it has been emancipated from some yoke and is intoxicated by the spirit of freedom and hope, then there is an outburst of music and song, and exquisite and grand creations of art." To stimulate the architect to do his best work, there must be an architecturally appreciative public, but public appreciation is worthless, if it be not "critical,—founded on knowledge and good taste." As indifference breeds ignorance, the British public, profoundly indifferent to architecture, is charged with being profoundly ignorant of it, and deficient in good taste. This popular lack of taste is responsible for the production of "an ostentatious class of buildings," which, Mr. Bidlake asserts, is vulgarizing whole districts. From the yield to the popular demand for this class of work, it must be inferred either that "there are architects as insensible to modesty and refinement in design" as the public, "or else that they are content to sacrifice whatever principles they may have in order to captivate the popular taste." The architects lack the healthy stimulus of a cultivated public opinion, and this reacts upon the public by placing it at the mercy of the architect. "The tender mercies of the architect may be very cruel. Having revived Greek, medieval, Gothic, or some other more or less unsuitable style, the architect will tell his client what is at present the fashion, and what is the proper thing to have, and the client, with British long-suffering, will pay heavily for being made miserable and uncomfortable until his lease of life runs out." This public ignorance and lack of taste in matters architectural is not to be wondered at, since the study of English architecture is not part of a curriculum. Even in the schools of art throughout the kingdom, while building construction may be taught, "the study of architectural history and design is conspicuous by its absence." The cause being pointed out, the remedy seems sufficiently obvious; but Mr. Bidwell is not content with a mere implication. He discusses this phase of the subject very explicitly. We quote him on one point,—"the public distrust of the architect on financial grounds." "It is often said that, if you go to an architect to build you a house, you never know when the expense will end. The client lays his wants before his architect, and tells him how much he is prepared to spend. Usually the sum is quite inadequate. Of course the architect tells him so? Not at all. He tells him that it will need economy, and implies that the design which he sub-

mits, and which meets his client's approval, can be carried out for the sum named. All goes well until the builder's tenders are opened, and then comes the disillusionment of the client. The lowest tender is half as much again as the sum to be spent. The architect anticipated as much, but he trusted to his power to surmount the difficulty when the time came." This is a common occurrence. But the architect is not without excuse. "How much more confidence would a client have in his architect . . . if the latter told him at once that it would be impossible to erect the building for the sum named?" Not any more. "He would doubt the architect's judgment, and say that Mr. So-and-So had built a house of similar size for less money, and eventually he would consult another architect . . . willing to mislead him." Nevertheless, the straightforward way is, in the long run, the best way. It will in time secure "the rare distinction of being regarded as an architect whose estimate can be trusted, and that means . . . a practice based upon the most solid foundation."

A Proposed Irish-Channel Tunnel.

"A SCHEME second to none in the annals of engineering" is the expression employed by Mr. J. Ferguson Walker, in the *Contemporary Review* for March, to characterize the project of connecting the islands of Great Britain and Ireland by a channel tunnel, affording thus continuous railway communication between London and Dublin. Without pausing to note the political reasons assigned by Mr. Walker for considering this subject at present, we pass to the various schemes for uniting the two islands that have, from time to time, been projected. These include "causeway, bridge, submerged tube, and tunnel." The project of a causeway was brought forward in the sixties by a member of the bar, and obtained some mention in the house of commons at the time. "The Land Junction of Great Britain and Ireland by an Isthmus at the Mull of Cantyre" is the title of a pamphlet written "about fifteen years ago by Mr. J. Charles King." It reached a second edition. The author's estimate of cost was £2,000,000, but other authorities estimated it at £70,000,000,—a rather noticeable difference of opinion, from which it may probably be inferred that any approximately accurate judgment of the probable cost could not be made by any one. A channel bridge, which would probably cost from thirty to forty millions of pounds (on the assumption that it could be built at all), has been proposed. Mr. Walker asserts that the question of cost is fatal to all these schemes, not excepting the scheme of Ernest A. Le Sueur, who proposed, in 1894 through the medium of the *Popular Science Monthly*, to dam up the waters of the channel, for the purpose, chiefly, of obtaining a motive power that would supply the whole United Kingdom with electricity. Such a dam would also supply the desired support for a railway track, but, as Col. Eschol Sellers would have said, "this is only a side issue" in the scheme. Mr. Walker declares the project of an isthmus between the north of Scotland and the Mull of Cantyre to be entirely worthless for railway purposes, because the present means of communication is quicker than that ever could be; and a further objection to this scheme is that it would probably leave the ports of Glasgow, Liverpool, Belfast, and Dublin high and dry. The submerged tubular bridge proposed by Mr. Maxton about six years ago is, in the opinion of Mr. Walker, the only rival of the tunnel scheme. The cost is estimated at £5,250,000, but he believes the admittedly somewhat greater cost of a tunnel would be more than compensated by the greater safety. The idea of tunnelling the channel was first seriously proposed by Messrs. Maccassey and Scott in 1868. At the time the practicability of the project was considered doubtful, and it was criticised as not having been worked out in sufficient detail. In 1882 the subject was again agitated, and "was publicly advocated on many occasions." Lord Wolseley favored it, believing it to be more desirable than the much-mooted English channel tunnel. In that year, also, letters favoring a tunnel "from Laggan Head to

the Maiden Islands, near Larne, and thence to the coast of Antrim" were published in *The Railway News*. One important reason for favoring this route was that it would avoid the narrow loch in the bottom of the channel, known as Beaufort's Dyke, which is 150 fathoms, and is situated between the coasts of Wigstoneshire and Antrim. Sir Edward Watkin favored the scheme of a tunnel, and even went so far as to employ a staff of surveyors to examine the route corresponding with the shortest sea-passage between the coasts, known as the Portpatrick and Donaghadee route. In 1886 the subject was twice mentioned in the house of commons, but was not favorably received; the project was still discussed, however, in various quarters. In 1888 Mr. Gladstone's speech advocating the proposed English channel tunnel called forth a pamphlet from Hon. F. Lawley favoring an Irish channel tunnel instead. In February, 1892, the subject was again brought up at the annual meeting of the chamber of commerce in Belfast. The scheme "was warmly supported by Sir Wm. Q. Ewart, . . . and during the month of February the Edinburg and Belfast newspapers were deluged with letters on the question." In March of that year Mr. F. W. M'Cullough, civil engineer, published a comparison of the merits and demerits of the different routes proposed, and arrived at the conclusion that the best route would be from Whitehead to Portpatrick. In April of the same year Mr. Maxton brought out his scheme for a channel tube. Messrs. James and John G. Barton, civil engineers, of Dundalk, in connection with Messrs. Hawkshaw & Hayter, a firm of London engineers previously engaged on the Severn tunnel, having made investigations, a public meeting was called by the mayor of Dublin to hear the results in detail. The names signed to the call for this meeting indicated that the movement did not lack influential support. These engineers advocated a new route (The Gobbins in the Island Magee to Portobello), and the practicability of the scheme, with many other propositions and facts relating to sub-aqueous tunnels, was so thoroughly debated that the question of a tunnel was left "in a very different position from what it had occupied before." It was made clear that there are no insuperable obstacles to the execution of the work, should capital back it up with sufficient strength. In 1891 a discussion of the details of the various routes proposed were discussed in the Belfast Natural History and Philosophical Society. The project was urged by the *Spectator*, and in February Sir Roper Letheridge read a paper, entitled "The Proposed Irish Tunnel," before the Society of Arts. It elicited much discussion. The result of all this agitation has been the formation of the opinion held by able engineers and statesmen that such a tunnel is practicable and desirable; and Mr. Walker appears to have been convinced that such a tunnel will ultimately be constructed. With such a connection passengers could take trains to Londonderry or Sligo, and from these points could reach Nova Scotia by steamer in four days. Mr. Walker makes an elaborate attempt to forecast the extent of probable traffic through a tunnel from Whitehead to Portpatrick, and thinks it would pay a 2½ per cent. dividend on the capital required for construction and operation.

Ropeways.

AN abstract of a paper read by Mr. W. Carrington, M. Inst. C. E., at the last meeting of the Federated Institution of Mining Engineers is given in *The Colliery Guardian* (March 19). The paper described the various types of ropeways, discussed their mechanical construction, and pointed out that the selection of a type of ropeway for a particular service should depend upon the character of the country to be traversed, the materials to be transported, the inclines to be surmounted, the quantity to be transported daily, etc. The attempt to make a single type of ropeway answer for any situation and all requirements has, in the author's opinion, brought undeserved discredit on the system of wire-rope transport,—a system which can do thoroughly efficient and satisfactory work, and can compete well with the or-

dinary ground railways of the class found in mines. The practical introduction of wire ropes for the carriage of loads to any notable commercial extent is credited to Charles Hodgson, who erected a ropeway at Bardon Hill quarries, near Leicester, England (date not stated), believed to be the first erected on any system similar to those now in use. Hodgson patented two systems, one an endless wire rope (speed about four miles per hour) on which the loads were supported and with which they moved, and a second wherein the loads were hung upon two fixed ropes and moved by an endless hauling rope, by means of which the motion was given to the carriers. This system has been most largely used on the European continent, while the running-rope system has been most employed in the British colonies. The running-rope system was for years the only system used in the United States, but more recently the fixed-rope system has very successfully competed with it. Mr. Carrington classifies ropeways into five types; (1) the endless running rope (greatly improved in all its details since its first use at Bardon Hill quarries); (2) an endless-rope type of ropeway, with the carriers rigidly attached to the rope; (3) the fixed-rope type,—two ropes,—also much improved since its first invention; (4) the single fixed-rope type, in which one carrier is drawn to and fro by an endless hauling rope; and (5) two fixed ropes with an endless hauling rope, in which one carrier travels on one fixed rope in an opposite direction to that in which another carrier moves on the other fixed rope. Of these each is better adapted to a certain set of conditions than any of the others. The endless mining rope is considered the most suitable for use where the quantity to be carried does not exceed 400 to 500 tons in 10 hours, where inclines do not exceed 1 in 3, where a single load does not exceed 6 cwt., and where no spans exceeding 600 feet are required. The endless rope with fixed carriers is preferable where there are very steep inclines, with sudden and frequent changes of level. The fixed parallel rope type should be used where the quantities to be transported exceed 500 tons per day of ten hours (grouped lines of the first type may be used instead), where the single load exceeds 6 cwt., where inclines exceed 1 in 2 or 3, and where spans exceed 600 to 1,000 feet. The single fixed-rope system is most suitable for the transport of moderate quantities *per diem*, in heavy single loads, over long spans and steep inclines. The use of two fixed ropes with an endless hauling rope which moves the two carriers in opposite directions is more suitable when the quantity to be moved is not enough to justify the use of No. 3, where the single load is heavy, where spans are long, and when simplicity of detail is desirable. It is said to be cheaper in cost and maintenance, and its operation requires fewer men. Loads of two or three tons can thus be carried over very long spans under favoring circumstances.

The Bertrand-Thiel Open-Hearth Process.

THE belief expressed at the close of the article upon this process in our March number is somewhat shaken by the adverse remarks made by open-hearth steel makers in the discussion that followed the reading of Mr. Gilchrist's paper, and by the comments that have appeared in the technical press,—for example, *The Engineer* (London, Feb. 5), which says "the general tone of the discussion, although very sympathetic, was not in the direction of accepting the author's conclusions in their entirety." Most of those who took part in the discussion appeared to think that the rapid working of the charges described by Mr. Gilchrist was due to the large amount of scrap in the charges. Mr. J. H. Darby, of Brymbo, referred to the observations of his brother at Kladno, as indicating that, when thirteen tons of high phosphorus pig was heated with four tons of scrap, the time for working off the charge was about the same as in the ordinary way (about twelve hours). A want of clearness in statement in some points was charged by Mr. J. E. Stead. For instance, he stated that "the paper was not clear as to whether the increased percentage of pig in the charge had increased the absolute yield of steel ingots." He intimated also that "the enticing reaction between

the metalloids and iron ore added, as a means of increasing the yield of steel above that charged as pig iron, was subject to the objection that the productive capacity of the furnace was reduced, owing to the greater length of time required." He regarded "the rapidity of action of the secondary furnace as due rather to the violent agitation produced by the mixing of the two charges than to any extremely high temperature in the metal." The brown smoke emitted from the metal, described by Mr. Gilchrist and regarded by the latter as evidence of a very high temperature, was said by Mr. Stead not to warrant the inference that the heat was "anything like that of the boiling-point of iron." Mr. Ainsworth, another open-hearth steel maker, gave it as his opinion that "this brown smoke was commonly seen in working Siemens furnaces." In short, a general skepticism was apparent, which Mr. Gilchrist did not wholly allay in his replies to the various queries and objections put forward. It is probably wise to reserve judgment upon this process till future developments shall have tested the conclusions reached by Mr. Gilchrist.

Prevention of Fires Due to Leaks from Wires.

THE efficient aid rendered by fire-insurance companies in devising rules for the safe use of electric currents for power and lighting having very much greater strength than those previously employed for telegraphy is fully acknowledged by Mr. Frederick Bathurst, A. I. E. E., in his Fothergill prize essay (*Journal of the Society of Arts*, Mar. 12). In his opinion the introduction and use of electric current for illumination and power purposes would have been seriously retarded, except for this timely assistance. At the same time it is intimated that these rules act now, in some measure, as a bar to progress, as, with the lapse of time, "conditions are arising which prevent their rigid and consistent enforcement." While there is a much greater degree of confidence as to the relative safety of the electric light than formerly existed, there still "lurks ominously in the public mind an undefined presentiment that electricity and electric fittings of all kinds are in some way 'dangerous'—if only as presenting to the lay mind the possibility of an accidental shock." The author states the problem of safe wiring to be identical with the adoption of the best means of insulation,—a remark that will seem rather trite to electrical engineers; but his enumeration of principles and discussion of the conditions under which they have to be applied are good. He finds an analogy to the evolution of safe wiring methods in the earlier history of the introduction of illuminating gas, wherein the use of glass tubes, tinned iron, or copper pipes led finally to the use of iron pipes, through the use at first of old gun-barrels. These having demonstrated that iron piping was the proper thing, the manufacture of iron gas-pipe was begun. The first gas-pipes were heavy and expensive. Not till the year 1825 were iron gas-pipes produced by machinery and approximating the present lightness of such pipes. Electricity, unlike gas, needs a solid, instead of a hollow, conductor. Copper has proved the transmitter, *par excellence*, of electric energy, and it is as universally used for this purpose as iron pipes for conveying gas. To confine the current of energy to the solid copper wire a covering more or less resistant to the passage of the current is placed around the wire. The covering, being continuous, has the form of a tube slipped on over the wire,—another analogy between the conduct of electricity and of gas from one point to another. The electromotive force tends to force electricity out of the prescribed path through the insulating covering, in a manner analogous to the tendency of gas to escape through holes or imperfect joints in piping. In both cases the higher the pressure, the greater is the tendency to escape, and the more will actually flow through any open outlet. Defects in insulation are analogous to openings in gas-pipes. The imperviousness of a gas-pipe depends upon the quality of the metal from which it is made, the quality of the fittings used, and the skill with which the fitting is performed. So, also,

the electrical imperviousness of the insulating covering of a copper wire depends upon the quality of the insulating material, and the skill with which it is applied to the wire. A pipe originally impervious to gas may become pervious by the action of exterior substances brought into contact with it. Similarly, an insulating coating may be made pervious to the electric current. The coating may be destroyed by such contact with a destructive agent, or it may be rendered pervious by contact with a substance—for example, moisture—which, without directly destroying, neutralizes more or less its power to insulate. But, when the current escapes through a porous insulator rendered ineffective by absorbed moisture, it generates heat, and may, by charring, destroy the insulating quality of the material, so that, when subsequently dried, it is no longer a good insulator. Those who wish to follow out these analogies will find abundant material in Mr. Bathurst's essay. We shall here trace them no further. Most leaks begin with small, incipient faults that increase as the leakage goes on. "They are not at first readily detected,—usually only when a sensational notice of the defect is given. This possibility further accentuates the necessity of insisting upon good work and the right conditions to start with. An insulator, to be perfect, should be one that will keep its insulating properties under all conditions of temperature, being non-corrodible, durable, moisture-proof, fire-resisting, and a reliable armoring. This combination of qualities is at present only partially provided in commercial work; and, considering the growing tendency to increase the voltage of supply, this insulation problem represents a strife between the power of penetrating and the power of resisting, with an all too favorable possibility on the side of penetration." The heating effect of a current increasing as the square of the amperage, a short circuit rush at a defective point can easily become so great as to fuse the conductor. Of course any combustible material in contact with, or near too, the point where such heating occurs is liable to ignite, and thus start a fire in a building. The safety fuses used to prevent such accidents have limitations. Some time elapses before such fuses heat to the fusing-point, and they do not give protection against leaks which are less than those required to fuse them. In other words, a fuse of five-ampere capacity will not prevent a four-ampere leak, and a leakage current of two amperes can cause a fire. The insurance companies name the following as sources of danger from electric wires: "(1) inferior materials and workmanship; (2) conductors of inadequate size and conductivity; (3) perishable and inferior insulating materials; (4) dust, dirt, and moisture; (5) undue heating; and (6) neglect of frequent testing and inspection." Mr. Bathurst summarizes the conditions of danger under three headings, which, he claims, include in broader terms all specified by the companies. His categories are: "(*a*) imperfect insulation; (*b*) imperfect conductivity; and (*c*) imperfect workmanship." Seventy per cent. of electrically-caused fires result from defective conductivity and insulation, and the remaining thirty per cent. from imperfect workmanship. Fully one-third of the conductor troubles come from crosses between wires of different systems. The breaking down of insulation under excessive voltage is also a frequent cause of fires.

Increased Use of Glazed Bricks for Building Purposes.

BOTH for exterior and interior work the use of glazed bricks in building is notably on the increase. "They possess," says *The Builder* (London, Feb. 27) "several advantages over plaster and other wall surfaces, but they also have some disadvantages. They are practically impervious to moisture, easily cleaned, and proof against the acids present in the air and rain. On the other hand, some glazed bricks are easily chipped or cracked, and the glaze may soon be stripped by frost." The best glazed bricks made in England are those produced in the vicinity of Leeds and Halifax. The common salt-glazed bricks are far inferior to "the specially-prepared pressed brick, the face of which is dipped into a 'slip' of fine clay before being fired and salted." The common

glazed bricks are glazed by salt thrown into the kiln. These are chiefly used for sewers, manholes, etc., where a clean, impervious surface, costing little, is desired. As a rule, they are not considered suitable for external or internal face-work. "Dipped bricks, known as *best* salt-glazed, are also used in manholes, but more largely in urinals, for dadoes and other internal work, and also for external work, chiefly in plinths . . . ; but occasionally for the whole front of a building. Dipped bricks are first pressed, and, while still green, their faces are dipped into a 'slip' of fine clay carefully weathered and ground, and sifted through fine silk sieves." This clay must be of the same kind as that in the body of the brick, to prevent crazing or shelling off as a result of uneven contraction in the kiln. A good salt-glazed brick is alleged to be almost as smooth as an enamelled brick, and, possessing other desirable qualities is now a formidable rival of the latter. In fact, it has the advantage that its glazing penetrates and is an integral part of the surface, while in the enamelled brick the glazing is a layer of foreign material—porcelain or earthenware—fused fast to the surface. Glazed bricks, besides being of unquestionable durability, are preferable as a material for building, on account of the great variety of color, varying from orange or light red to a deep red brown, which "adds a great charm to finished work." An account of the processes employed in the manufacture of glazed bricks, and of the accidents liable to occur in firing, adds interest to the article.

The Ashcroft Processes for the Electrolytic Treatment of Ores.

WE find in the *Australian Mining Standard* (Jan. 20) an article devoted to a general description of the above processes, which are claimed to be the first to deal successfully with the difficulties of treating electrolytically the sulphid ores on a commercial scale. The processes, having been tested, are about to be put into practical operation at Cockle Creek, near Newcastle, in New South Wales. They are the more interesting on account of their invention by a young electrician, who, though not a metallurgist, discovered the solution of the problem that had hitherto baffled those skilled in the art of extracting metals from ores. It is not claimed that the idea of treating this class of ores electrolytically was new when Mr. Ashcroft essayed its development. "On the contrary, the problem had been often approached, with the result that every inventor had been beaten back with heavy loss, in spite of the many successes which had been from time to time reported." Mr. Ashcroft, having installed an electric lighting station for the Broken Hill Proprietary Company, whose mines had developed enormous masses of zinciferous galena, remained as engineer in charge of the station. That company having called to their aid Dr. Schnabel, an expert metallurgist, to advise as to the best method of treating this ore, Mr. Ashcroft assisted him in preparing a report which was considered very able and exhaustive. This report did little more toward the solution of the problem than to place in a strong light the utter and total inadequacy of the ordinary operations of metallurgy to deal with the difficulties presented by this class of ores. Two conclusions arrived at were that "it would pay to take the ore to the coal, rather than to bring the coal to the ore," and that any successful process must proceed on the lines of leaching out the zinc before the lead and silver were subjected to furnace treatment. Sulphuric or sulphurous acids were indicated as the most promising leaching reagents. Thus the problem came before Mr. Ashcroft, who, besides being "a trained electrical and mechanical engineer, had also a good knowledge of chemical principles." The works at Cockle Creek are designed to treat some two millions of tons of sulphid ores which are already exposed. It is said that this ore averages thirty per cent. of lead, thirty per cent. of zinc, and twenty-five ounces of silver per ton. It is expected to handle five thousand tons of this ore per week, when the installation gets into full operation. The process is cyclic. The ore is first ground fine, and then roasted at a temperature so low that, while the lead and zinc sulphids are converted

into oxids, sulphates, and basic sulphates, the silicates in the ore are not caked. The roasted ore is then leached in shallow vats with ferric chlorid (ten grammes of iron per liter) and an equivalent of sodium sulphate.

The zinc oxid is dissolved as zinc chlorid, while the sodium sulphate prevents solution of the lead; but "some iron and manganese, and a trace of silver, go into solution with the zinc chlorid." When the solution gets a strength of about thirty grams of zinc per liter, the leaching is discontinued. The ferric oxid carried off in considerable quantity in the solution is extracted in the purification process. In this part of the operation the solution is heated by injection of steam, and small quantities of bleaching powder are added, which changes ferrous iron to the ferric state; a small quantity of zinc oxid added brings down the iron. Large agitators are used for this purification. The liquor is filtered, and the cakes of solid matter, rich in silver, left behind are added to the leached ore when it goes to the furnaces for smelting. Silver and traces of other metals are removed in another set of agitators, in which zinc is used as a precipitant. Aluminum and manganese remain in solution, but, as they do not interfere with the electrolytic treatment, it is not sought to remove them. The electrolysis of the purified solution is the next step. The process is so controlled that a bright, hard deposit of pure zinc is obtained, with a current of five amperes and a low electro-motive force, iron anodes being used, which lose one equivalent of iron for every equivalent of zinc deposited. The iron expended is of use in the smelting operations as a flux for the lead. "Chlorid of zinc, however, will not deposit well, if it carries much iron in solution, so that porous diaphragms have to be employed, in order to separate the anolyte from the katholyte." The order in which the electrolysis proceeds is as follows: "The purified chlorid of zinc flows past zinc kathodes of pure rolled zinc. It returns over iron anodes, where it takes into solution the ferrous equivalent of two-thirds of the zinc deposited; finally it passes as anolyte over carbon anodes, where it takes up chlorine equivalent to one-third of the zinc deposited." So far it has been found expedient to exhaust the solution to the extent of twelve grams of zinc per liter of the solution. The solution still containing much zinc is again used for leaching, and so on, over and over. The round of processes thus forms a cycle. The article reviewed presents engravings of the installation at Cockle Creek, and a portrait of the inventor.

THE FRENCH AND GERMAN PRESS

The Society of Civil Engineers of France.

THE completion of the new house for the French Society of Civil Engineers has been the occasion of several articles in the technical journals; the following account is condensed from the *Génie Civil*, the *Construction Moderne*, and the *Schweizerische Bauzeitung*.

The *Société des Ingénieure Civils de France* was organized in the stormy year 1848, with a membership of 134, while now, after fifty years, the membership has reached a total of 2,724, and the society stands as one of the leading professional organizations of Europe. Its monthly transactions, "*Mémoires et Compte-rendu des Travaux de la Société des Ingénieurs Civils de France*," are everywhere recognized as the record of the best typical work of French engineers, and membership in the society is an acknowledged mark of professional eminence.

Those American engineers who had the good fortune to be the guests of the French society during the exposition of 1889 will remember the then quarters in the Cité Rougemont, one of those curious little interior towns encysted, so to speak, in the heart of Paris; even then it was evident that the membership had outgrown the limited accommodations. The new building, recently finished upon ground purchased by the society in the rue Blanche, places the society on a level with the British Institution of Civil Engineers, so far as residence is concerned, and it is a question whether the house in Great George street is not fully equalled by the building in the rue Blanche.

The ground floor of the building contains a large entrance-vestibule, coat-room, lavatories, conversation- and smoking-room, and large meeting-hall. The last-named room, 72 by 49 feet, including the communicating conversation-room, is especially interesting because of the peculiar construction of the floor, whereby it may be mechanically lowered at the platform end and thus in a few minutes be converted into a sloping hall for meetings, or as readily made level when it is to be used for receptions, etc. This hall, being in the rear, is but one story high, with great arched ceiling 10 meters high, and ample skylight illumination.

On the upper floors are committee rooms, offices, etc., the second floor containing ample room for the valuable library, while on the third floor is a laboratory and photographic room and the residence of the general secretary, all rooms being lighted by electricity and warmed by hot water.

The building was constructed in the short space of nine months, from designs by Professor Delmas, and the severe architecture of the Louis XIV period is appropriately applied to the principal façade. The dedication ceremonies took place on January 14, President Faure assisting, and the congratulations of American engineers should be heartily extended to their French brothers upon the completion of the work.

The cost of the building alone was $110,000, to which must be added $80,000 for the ground, making a total of $190,000.

German Locomotives.

THE exhibition at Nuremberg last year was the occasion of the display of a number of locomotives showing the latest examples of design by the leading builders of Germany, and some notice of these, together with those shown at Berlin and at Budapest, has already been given in these columns. The issue of the *Zeitschrift des Vereines deutscher Ingenieure* for January 23 and February 13 contains an article devoted especially to the engines exhibited at Nuremberg, with numerous details and a full drawing of the special engine by Krauss, of Munich, as well as illustrations of the other locomotives shown; and the whole forms a very complete display of the latest types of German engines.

The author of the article, Herr Brückmann, enumerates the leading points of advance in the modern locomotives as follows:

(1) The introduction of much larger boilers, constructed for increased pressures; 180 to 200 pounds;

(2) The use of larger driving wheels, and consequent increase in the distance from the rails to the center of the boilers; 83 to 98 inches;

(3) The general introduction of swivel trucks, instead of the former rigid wheel base;

(4) The introduction of quick-acting automatic brakes, not only on the drivers, but also on the truck-wheels.

In addition to these mechanical changes there are the numerous arrangements for compounding, of which the engines at Nuremberg included a variety of types.

The most interesting engine shown was the compound, double-cylindered locomotive of Krauss, above referred to. Two engines of this type have been used by the Bavarian State Railway for a year. Primarily the engine is a two-cylinder compound with a single pair of 73-inch drivers, swivel truck, and single trailing axle.

In addition, however, there is an auxiliary axle between the main driving axle and the forward truck, carrying an independent pair of small drivers, forty inches in diameter, these being operated by a separate pair of cylinders situated directly underneath the main cylinders. The journal boxes of this auxiliary axle are connected by equalizing levers to the system of springs upon which the weight of the engine is supported, and under ordinary conditions the weight is distributed among all the wheels in proportion to their leverage. The auxiliary axle, however, is provided with a steam-pressure cylinder above it, so connected to the boiler that, when steam pressure is admitted above, a greatly-increased pressure is brought upon it; when the pressure is reversed, it may be lifted entirely out of contact with the rails.

This makes it possible to give a concentrated pressure upon the small drivers, which effectually prevents slipping and enables the entire power of the auxiliary engine to be available for starting or ascending steep grades, while upon all other portions of the road the large single drivers operated by the compound engine are alone used. The engine appears rather complicated, but is really not more so than some four-cylinder compounds, and certainly attacks the starting problem in an effective manner.

Krauss also exhibited a four-cylinder tandem engine of the trunk variety, which closely resembles in its cylinder arrangements some of the old horizontal marine compounds long since abandoned. A compound engine by Maffei, of Munich, has the high-pressure cylinders inside, connecting to the forward cranked axle, while the low-pressure cylinders are outside and connect to the two rear axles, all three axles being also coupled.

Another interesting engine was one of the so-called "Mallet" type, built for the Bavarian State Railways by Maffei. This locomotive differed from the ordinary Mallet engine in being compounded, one pair of cylinders being high-pressure and the other low-pressure, and the steam connection between the two swivel wheel bases being made by a peculiar flexible pipe constructed of a number of corrugated diaphragms riveted together.

In these exhibits there is seen the result of efforts to increase the economy by compounding, to increase the speed by higher pressures and better arrangement of parts, and to increase the tractive power by better distribution of weights. While many of the ideas show evidence of a transition state, they are for that very reason the more interesting, and, notwithstanding the different conditions which obtain in this country, there are many points of value to be gathered from the exhibits at Nuremberg.

The Monier System of Construction.

THE so-called Monier system of combined béton and metal construction is the subject of continual discussion in the technical press, especially the proper method of computing the proportion and strength of the relative parts.

Herr S. Rappaport, of St. Gall, contributes a lucid article on this subject to the *Schweizerische Bauzeitung* for February 27, from which we make extracts.

The idea of employing materials of different kinds to form a combination of superior economy or sustaining power is by no means new. It was not long after man conceived the construction of timber framing that it was seen that the use of iron for certain members would be accompanied with advantages, and the same line of reasoning doubtless led to the production of the Monier system. Béton possesses a high degree of resistance to compression, as does iron to tension; if, therefore, we can so arrange the construction that the compressive stresses shall be received by béton and the tensions by iron, good results should certainly be obtained.

In computing the relative proportions of the materials and their disposition, however, something more than their relative resistances must be considered, if the true value of the construction is to be realized. We must consider the relative *elasticity* under the existing conditions rather than the resistance to rupture. This is well seen if we carry the form of construction to an extreme,—such, for instance, as would be found in a beam of granite reinforced by a beam of rubber beneath, the whole supported at the ends and loaded in the center. It is very evident that rubber would add nothing to the strength of the granite, since the granite beam would be broken by a deflection so small that the rubber would not be subjected to any appreciable stretch. As soon, however, as the granite breaks, the entire load comes upon the rubber, which will then assume such a sag as will enable it to sustain the stress, or will break if its strength be exceeded.

In computing the proportions for such combinations, therefore, it is most essential that the various coefficients of elasticity be determined by careful experiments under conditions similar to those which obtain in actual practice. When this is done, the computations may be made with greater approach to accuracy than has heretofore been attempted.

In this connection we may also call attention to a very valuable series of tests upon the strength and elasticity of granite made by Herr C. Bach, and published in the issue of the *Zeitschr. d. Vereines deutscher Ingenieure* for February 27. The tests included resistance to compression, tension, shearing, and torsion, with especial reference to the modulus of elasticity, the results being both tabulated and expressed graphically.

The same article also includes a general discussion of the laws of elasticity, based upon the study of the behavior of various metals, stone, cement, mortar, and béton, with exponential formulas deduced from the experimental tests, for use in determining the extension, under any given case, for the various materials considered.

Automobile Vehicles in Warfare.

IN an article discussing the above subject in *La Revue Technique*, for February 25, Colonel Fix examines the requirements and conditions which must be met in order to achieve success.

Since all military vehicles must be both solid and simple, many features which might be otherwise acceptable must be omitted. Roads which in time of peace are good soon become neglected and demoralized in time of war, and a vehicle, like a soldier, should be able to accommodate itself to all inconveniences. Tires of rubber, whether pneumatic or solid, are inadmissible, both because of the greater weight to be carried and because of the rough usage to be endured. Iron tires alone meet the requirements, and, in view of the great torsional strains, the hubs should be larger than they would otherwise need to be, while, in order to clear surface obstacles, the diameter of the wheels should not be less than that now found in field artillery.

Electricity is barred as a motive power, on account of the impracticability of charging accumulators in the field or *en route*, and steam or petroleum motors alone remain, between these steam having the preference, at least for greater powers, since the petroleum motors at present have not proved satisfactory above 10 h. p.

Practically an automobile vehicle for military service must be a carefully-designed steam-traction engine, planned to

haul artillery and supply-trains anywhere where horses can go; the questions of speed and personal comfort, so important in pleasure vehicles, need hardly be considered.

Colonel Fix shows some very interesting figures relating to the cost of horses in military service, and makes out a strong case for the side of the machine, and it is not at all unlikely that the use of machinery in warfare may soon enter the field service as extensively as it has already entered other departments.

Granite Asphalt Paving.

ACCORDING to an article in *Le Génie Moderne* for February 15, Paris is not altogether satisfied with her fine wood pavements, realizing that, although wood, when maintained in perfect condition, is without a superior for driving or walking, it is far from being unobjectionable on hygienic grounds.

Asphalt alone has had ample trial in Paris, and the only objection which it has raised is that of extreme slipperiness; now a new combination called granite-asphalt is proposed.

This is simply a concrete composed of crushed granite and melted asphalt; when used for paving, it is spread upon a foundation bed of béton. The first layer upon the béton is a thin coating of asphalt alone, followed by a thicker layer of crushed granite,—not pebbles,—followed by a grouting of liquid asphalt mingled with finer crushed granite, rolled in as usual.

This pavement is said to possess all the desirable qualities of asphalt, together with a surface which does not become slippery in wet weather, and which is entirely impervious to all deleterious absorption. It has been used for some time in the cavalry barracks of Germany, and the tests made upon it by the Department of *Ponts et Chaussées*, in Paris, have given very satisfactory results.

Slag Cement.

THE extending use of slag as a material for cement, and the varied opinions as to its real value, render the account of the methods used at the large work at Vitry-le-Français, and published in the *Moniteur Industriel* for February 13, of value and interest.

The manufacture of slag cement consists of two distinct operations,—the selection and preparation of the powdered slag, and the incorporation of the lime. All slag is not adapted for the production of good cement, and both its composition and the manner of its preparation are matters of importance. The slag supplied to the above works comes from the blast furnaces at *Pont-à-Mousson*, and is especially satisfactory for cement, on account of the proportion of lime which it contains, and because of its uniform composition. Its average composition is:

Alumina	22
Silica	32
Lime	42
Oxids of iron, magnesia, etc.	4
	100

Black slags—*i. e.*, those containing a large proportion of metallic oxids—are unsuited for the production of good cement. Although the slag should be basic, the silico-aluminate should not contain an excess of lime, as it in that case becomes too fusible, and flows from the furnace before it has attained the proper temperature to develop the best hydraulic properties. It is also desirable that the slag should be suddenly cooled as soon as drawn from the furnace; this is effectively accomplished by directing against it a stream of water under high pressure, which delivers the slag into a basin of masonry, where it is deposited in a fine granular form. The granular material is then thoroughly dried in an oven upon sheet-iron plates at a temperature of about 1,000° F., diminishing gradually to about 300°. It is then finely ground and bolted, the product being a grayish meal, extremely fine and unctuous to the touch, and requiring only to be mixed with the proper proportion of lime to make the marketable cement.

The mixing with lime is effected in steel tumbling barrels, cast-iron balls being placed in the mass to render, by their motion, the mixture more intimate, the mix-

ture being completed in from sixty to eighty minutes. The proportion of lime varies from one-fourth to one-fifth part of the powdered slag by volume, a good hydraulic lime being employed. At Vitry the lime is produced in kilns belonging to the works.

Slag cement has been used very successfully in the manufacture of cement pipes, about one thousand pounds of cement being used to the cubic yard of siliceous sand. The pipes are formed by ramming in sheet-iron molds, and, after three days' drying, immersion in water for twenty-four hours. They are stacked in the yard for three or four months before using.

Electric Cranes.

THE electric traveling crane is distinctly an American invention, but is finding prompt acceptance abroad. Less than two years ago two small single-motor cranes in the new foundry of Gebrueder Sulzer at Winterthur were pointed out as great novelties, but now several such cranes are described and illustrated in an account of the electrical exhibition recently held at Stuttgart. A ten-ton three-motor traveling crane shown at this exhibition is illustrated and described in the *Zeitschrift des Vereines Deutscher Ingenieure* for January 16; while it shows a number of points of merit, it does not include the latest and best points of practice on this side.

The bridge travel is effected by a squaring shaft operated by its own motor, and this motor is properly placed in the middle of the shaft, in order that any torsion may affect both ends of the bridge alike; like the motors for hoisting and for trolley travel, it operates through worm gearing. The hoisting chain is wound over a pocketed sheave instead of around a drum, thus permitting all the defects which wear and stretch have been found to introduce, and there appears to be no method of lowering, except that of reversal of the motor. An automatic strap brake is provided, which assists the worm gearing to hold the load if the current should be interrupted, and the bridge and trolley are built up of wrought-iron sections in the manner now in general use. Under maximum load the speed of hoist is about 4 feet per minute, increasing for lighter loads to about 20 feet. The trolley travel is about 25 feet, and the bridge travel 50 feet, per minute, and the crane operates with a current of 120 volts' pressure.

Electric Steering Machinery.

THE use of electric power on shipboard is being extended to nearly all the functions formerly performed by auxiliary steam engines, and it is to be expected that the steam steering engines will prove no exception. The *Elektrotechnische Zeitschrift* (Feb. 4) gives an illustrated account of Essberger's electric steering gear, showing very clearly its arrangement and operation. The principle upon which this gear operates is that of two continuously-running motors coupled to an epicyclic train of gearing in such a manner that, when both motors run at the same speed, the motion of the final wheel is zero, but for any difference in speed the shaft is operated in one direction or the other. This "over-running," as it may be called, can continue only so long as the lever upon the bridge is moved, as otherwise a resistance interposes to check the overrunning motor, much in the same manner as the action of a steam steering gear is controlled.

Among the advantages of the electric gear, the greatest, of course, is the absence of the necessity of any mechanical connection between the bridge and the motor room; and the motor portion of the apparatus can be placed as near the rudder as convenient, the wires being readily run to the desired point of control.

It is also an improvement to have the motors continuously in motion. The rudder of a ship may require to be moved several thousand times a day, and the constant reversal of the engines forms a great part of the wear and tear upon a steam steering gear. Essberger's apparatus is now being introduced and tested in the German navy, and similar devices doubtless will be tried soon in the merchant marine.

The Liquefaction of Gases.

THE recent experiments of Professor C. Linde, of Munich, upon the simplification of apparatus for liquefying those gases which have a very low critical point have attracted considerable attention, and a description and illustration of his apparatus is given in the *Zeitschr. d. Oesterr. Ing. u. Arch. Vereines* for February 12.

As is well known, there is for every material a so-called critical temperature above which a gas cannot be liquefied, no matter how great the pressure exerted upon it, the gaseous form being retained for the smallest volume into which it can be compressed. In order, therefore, that a gas may be liquefied by pressure, it is necessary that it be maintained at a temperature below the critical point. For the following gases the critical temperatures are: water, 362° C.; bisulphid of carbon, 275° C.; alcohol, 259° C.; ether, 196° C.; carbonic acid, 31° C.; oxygen, —118° C.; carbonic oxid, —140° C.; nitrogen, —145° C.

To liquefy atmospheric air, therefore, it is necessary that the temperature be reduced to the critical point of nitrogen,—*i. e.*, below —145° C. The usual method of reaching this very low temperature is first to liquefy by pressure some gas which has a critical point readily attained, and then, by permitting this liquid to evaporate at a lower pressure, to produce a much lower temperature, under the influence of which a second gas may be liquefied. By thus proceeding in several stages, the very low critical points may be reached, and it was by this method that Cailletet and Pictet succeeded in bringing oxygen, nitrogen, and even hydrogen to the liquid state.

Prof. Linde, however, has succeeded in dispensing altogether with the auxiliary apparatus for lowering the temperature, and uses instead the expansion of a portion of the already compressed gas which it is desired to liquefy. Briefly, the principal portion of the apparatus consists of a pair of concentric tubes, the compressed gas being allowed partly to expand as it enters the inner one and then returned to the compressor through the annular space between the tubes, where it is cooled by the absorption of heat by the expanding gas. The heat generated by the compression is removed by a separate cooler, and the operation may be continued indefinitely, or until the critical point of the gas is reached, when it is delivered in the liquid form in a collecting vessel.

With this apparatus air has been liquefied by compressing it to about 900 pounds per square inch, and subsequently expanding it to 300 pounds, in continuous cycle, the temperature being lowered by the expansion until the latter pressure was sufficient to produce the liquefaction. The liquid air, when drawn off in a glass beaker, well protected against access of heat, appeared as a pale bluish liquid, slightly milky from particles of solidified carbonic acid. Since nitrogen has a lower boiling-point than oxygen, the former at once began to evaporate, and the remaining liquid thus became constantly richer in oxygen, the temperature rising in half an hour from —189.1° to —184.8° C.

An interesting deduction in this connection is that of the reduction of electrical resistance for low temperatures. According to Holborn & Wien, who have determined the electrical resistance of platinum at o° C., at the temperature of liquid carbonic acid, and at the temperature of liquid air, the relation of the temperature to the resistance may be expressed by the equation:

$$t = -258.3 + 5.0567\,R + 0.005855\,R^2.$$

If this relation continues to hold good for temperatures below that of liquid air, it follows from the formula that at a temperature of —258.3 C. the resistance of platinum would become zero.

The Dusseldorf Bridge.

A NUMBER of long-span bridges have lately been constructed and projected in Germany; among those projected the Düsseldorf bridge possesses several points of interest. From an article by Herr R. Krohn in the issue of the *Zeitschr. des Ver. deutscher Ingenieure* for February 13 the following facts are obtained:

Düsseldorf is situated at a sharp bend in the Rhine, on the outer side of the bend; on the opposite side of the Rhine the low-lying land is protected against

floods by a dike. The present means of communication between the two banks is a floating pontoon bridge. The construction of a permanent bridge at Düsseldorf has been frequently discussed, but, as this always involved the improvement of the left bank of the stream, the expense has heretofore been too great an obstacle.

Moreover, the city authorities have always maintained that a bridge would be of small benefit to the municipality, holding that the improvement would be mainly in the value of property on the opposite bank. Taking advantage of this short-sighted policy, a company of capitalists has obtained a concession by which the company secures a large slice of the land, now frequently under water, but lying directly opposite the city, and also the right to build a bridge, the State undertaking the regulation of the river so far as to build a new dike about one thousand feet further out, dredging the material beyond and filling it in behind the embankment. The company also owns the right for a tramway to Crefeld, about ten miles away.

In this way the city will get a fine new bridge at small cost, while the company expects to be fully repaid by the advanced value of the reclaimed land, which, will be placed within a few minutes of the heart of Düsseldorf. The company also takes all the tolls on the bridge, and runs its tramway across to the city.

The design for the bridge is excellent, and consists of two great steel arches, each with a span of 594 feet, the roadway being suspended at the level of the springing of the arches. Three smaller spans on the left bank, and one on the right, complete the bridge, making a total length of more than two thousand feet. The plans were made by the Gutehoffnungshütte, by which company the ironwork will be executed, and one of the conditions of the concession is the maintenance of an uninterrupted waterway of 160 feet in width during the entire period of construction. The construction of the piers was begun last summer, and the bridge is expected to be opened for travel by the close of 1898.

Acetylene.

THE interest in the development of acetylene as an illuminating agent seems to be rather on the increase abroad, possibly owing to judicious commercial demonstrations; and, apart from the strict police regulations enforced in Berlin since the fatal explosion of liquefied acetylene there, its progress has been marked.

An exhibition of a generator was given before a committee of the Austrian Society of Engineers by the company which has the development of the new illuminant in Vienna, and a report of the meeting, which took place on February 9, is given in full in the *Zeitschr. d. Oesterr. Ing. u. Arch. Vereines* for February 26.

According to Professor Lippmann, the first definite isolation of acetylene was that of Berthelot in 1859, who produced it by decomposing various organic compounds, such as alcohol, ether, etc., by the electric spark or in red-hot tubes, and also synthetically by surrounding the electric arc between carbon points with hydrogen.

The apparatus shown in Vienna was practically the same as the well-known generator for sulphuretted hydrogen, used in every laboratory, exeept that the sulphid of iron is replaced by calcium carbid and the sulphuric acid by water. The carbid being placed in a tight vessel submerged in a tank of water, the water is allowed to enter through a small pipe rising from the bottom nearly to the top of the generator. As the acetylene is generated, its pressure increases until further entrance of water is stopped, when the generation of gas ceases; when the pressure is reduced by drawing off the gas, the water again enters.

Especial emphasis was laid by Prof. Lippmann upon the fact that disastrous explosions were due only to the careless use of the liquefied gas. The explosion at Pictet's laboratory in Paris was due to the compression in a vice of a cylinder of the gas under the impression that it was empty, while the disastrous explosion at Isaac's workshop in Berlin was caused by the heating of a steel cylinder full of the liquefied gas,—an event which would have occurred with any gas.

A New Copper Alloy.

A NEW competitor in the field of materials of construction has appeared in the form of the so-called Durana metal, an alloy of copper which has certainly shown most remarkable properties, according to the account given by Professor Dr. Dürre in the *Schweizerische Bauzeitung* for March 6. Durana metal is an alloy of copper made by the firm of Hupertz & Harkort, of Duren, in Rhenish Prussia, and the peculiar properties which it possesses, as well as the very high tests which it has shown, should make it a most valuable addition to the long line of copper alloys already in use.

According to Dr. Dürre, Durana metal has a melting point not greatly different from that of the ordinary bronzes, so that it can be melted and cast in the ordinary brass furnace, its fluidity enabling excellent castings to be made without difficulty. When carefully heated in a suitable furnace, it may be readily wrought, the temperature being raised to a point between a dark and a cherry red. This malleability enables it to be worked under the hammer and in the rolls, until the redness has entirely disappeared, its behavior under these conditions being that of a very soft wrought iron, showing none of the extraordinary hardness and resistance which appear at ordinary temperatures.

The makers have succeeded in producing four different varieties of Durana metal, which have shown, under many hundreds of tests, the following results :

	Ultimate Strength.	Elastic Limit.	Extension.
Hard alloy	90,000 lbs.	74,000 lbs.	9%
Medium "	72,500 "	60,000 "	12%
Soft "	57,000 "	50,000 "	31%
Very soft "	45,000 "	20,000 "	50%

When to these valuable properties are added so low a specific gravity as 8.3 and a high resistance to oxidation, we see that the new metal has claims to consideration.

Nationality of Travelers.

THE frequency with which the railways are used in the various countries of Europe has been tabulated with somewhat interesting results, according to an item in the *Oesterr. Monantschr. f. d. oeff. Baudienst.* England, with its 38,000,000 inhabitants, leads, with 864,500,000 travelers on its railways every year, or 23 travelers to each inhabitant. Belgium comes next, with 86,500,000 travelers for 6,000,000 people, or 14 to 1. Germany holds the third place, having 483,000,000 travelers to 49,000,000 people,—a ratio of 10 to 1. After which come in the order named: Holland, with 7 to 1; France, 6 to 1; Austria, 4 to 1; Hungary, 3 to 1; and Italy, with only two travelers to each inhabitant. The smallest travel in proportion to the population is found on the Russian railways, where there are 3 inhabitants for every traveler each year.

A New Engineering Review.

THE appearance of Vol. I, No. 1, in any line of publication is not always cause for congratulation, but it requires no dissimuation on our part to extend a hearty welcome to the new-comer into the field of engineering journalism, the *Revue de Mecanique.*

When a review, devoted to mechanical engineering, bears upon its editorial committee such names as those of MM. Haton de la Goupilliere, Gustave Richard, Hirsch, Raffard, and others of like standing and reputation, its position is established in advance; and this promise is already redeemed by the appearance of contributions by MM. Dwelshauvers-Dery, Boulvin, Sauvage, and Richard.

As indicated in the programme laid out by the committee, the new review is to be devoted to the production of articles upon selected subjects in mechanical engineering, bearing upon original investigations, either theoretical or experimental, and forming complete monographs upon distinct groups of machines of exceptional importance. Most of the contributions take the form of serial articles, so that it is not possible immediately to review in these columns the first instalments, but the substance of the various monographs will be taken up here, as their progress permits, and in the meantime the new journal is welcome and recommended.

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American Geologist. *m.* $3.50. Minneapolis.
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American Shipbuilder. *w.* $2. New York.
Am. Soc. of Irrigation Engineers. *qr.* $4. Denver.
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Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
Annales des Ponts et Chaussées. *m.* 31 francs. Paris.
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Architectural Record. *q.* $1. New York.
Architectural Review. *s-q.* $5. Boston.
Architecture and Building. *w.* $4 New York.
Architektonische Rundschau. *m.* 18 marks. Stuttgart.
Arena, The *m.*. $5. Boston.
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Australian Mining Standard. *w.* 30*s.* Sydney.
Baker's Railway Magazine. *m.* $2. N. Y.
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Engineer, The. *s-m.* $2. New York.
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Inland Architect. *m.* $5. Chicago.
Iron Age, The. *w.* $4.50. New York.
Iron and Coal Trade Review. *w.* 30*s.* 4*d.* London
Iron & Steel Trades' Journal. *w.* 25*s.* London
Iron Trade Review. *w.* $3. Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* $5. Wash.
Journal Assoc. Eng. Society. *m.* $3. St. Louis.
Journal Franklin Institute. *m.* $5. Phila.
Journal of Gas Lighting. *w.* London.
Jour. N. E. Waterw. Assoc. *q.* $2. New London.
Journal Political Economy. *q.* $3. Chicago.
Journal Royal Inst. of Brit. Arch. *s-q.* 6*s.* London.
Journal of the Society of Arts. *w.* London.
Journal of the Western Society of Engineers. *b-m* $2. Chicago.
Kansas University Quarterly. *qr.* $2. Lawrence, Kan.
La Nature. *w.* 24.50 francs. Paris.
La Révue Technique. *b-m.* 28 francs. Paris.
L'Eclairage Electrique. 60 fr. Paris.
Le Génie Civil. *w.* 45 fr. Paris.
L'Electricien. *w.* 25 fr. Paris.
Le Moniteur des Architectes. *m.* 33 francs. Paris.
Le Moniteur Industriel. *w.* 40 francs. Paris.
Locomotive Engineering. *m.* $2. New York.
Machinery *m.* $1. New York.
Machinery. *m.* 9*s.* London.
Manufacturer's Record. *w.* $4. Baltimore.
Marine Engineer. *m.* 7*s.* 6*d.* London.
Master Steam Fitter. *m.* $1. Chicago.
Mechanical World. *w.* 8*s.* 8*d.* London.
McClure's Magazine. *m.* $1. New York.
Metal Worker. *w.* $2. New York.
Mining and Sci. Press. *w.* $3. San Francisco.
Mining Industry and Review. *w.* $2. Denver.
Mining Journal, The. *w.* £1. 8*s.* London.
Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnwesens. *m.* fl., 12. Vienna.
Monatsschrift des Württ. Vereines für Baukunde. 10 parts yearly. 3 marks. Stuttgart.
Municipal Engineering. *m.* $2. Indianapolis.
National Builder. *m.* $3. Chicago.
Nature. *w.* $7. London.
New Science Review, The. *qr.* $2. New York.
Nineteenth Century. *m.* $4.50. London
North American Review. *m.* $5. New York
Oesterreichische Monatsschrift für den Oeffentlichen Baudienst. *m.* 14 marks. Vienna.
Oesterr. Zeitschrift für Berg- & Hüttenwesen. *w.* 24 marks. Vienna.
Physical Review, The. *b-m.* $3. New York.
Plumber and Decorator. *m.* 6*s.* 6*d.* London.
Popular Science Monthly. *m.* $5. New York.
Power. *m.* $1. New York.
Practical Engineer. *w.* 10*s.* London.
Proceedings Engineer's Club. *q.* $2. Phila.
Proceedings of Central Railway Club.
Pro. of Purdue Soc. of Civ. Engs. *yr.* 50 cts. La Fayette, Ind.
Progressive Age. *s-m.* $3. New York.
Railroad Car Journal. *m.* $1. New York.
Railroad Gazette. *w.* $4.20. New York.
Railway Age. *w.* $4. Chicago.
Railway Magazine. *m.* $2. New York.
Railway Master Mechanic *m.* $1. Chicago.
Railway Press, The. *m.* 7*s.* London.
Railway Review. *w.* $4. Chicago.
Railway World. *m.* 5*s.* London.
Review of Reviews. *m.* $2.50. New York.
Safety Valve. *m.* $1. New York.
Sanitarian. *m.* $4. Brooklyn.
Sanitary Plumber. *s-m.* $2. New York.
Sanitary Record. *m.* 10*s.* London.
School of Mines Quarterly. $2. New York.
Schweitzerisches Bauwesen. *w.* 20 marks. Zurich.
Science. *w.* $5. Lancaster, Pa.
Scientific American. *w.* $3. New York.
Scientific Am. Supplement. *w.* $5. New York.
Scientific Machinist. *s-m.* $1.50. Cleveland, O.
Scribner's Magazine. *m.* $3. New York.
Seaboard. *w.* $2. New York.
Sibley Journal of Eng. *m.* $2. Ithaca, N. Y.
Southern Architect. *m.* $2. Atlanta.
Stahl und Eisen. *s-m.* 20 marks. Dusseldorf.
Stationary Engineer. *m.* $1. Chicago.
Steamship. *m.* Leith, Scotland.
Stevens' Indicator. *qr.* $1.50. Hoboken.
Stone. *m.* $2. Chicago
Street Railway Journal. *m.* $4. New York.
Street Railway Review. *m.* $2. Chicago.
Technology Quarterly. $3. Boston.
Tradesman. *s-m.* $2. Chattanooga, Tenn
Trans. Assn. Civil Engs. of Cornell Univ. Ithaca.
Trans. Am. Ins. Electrical Eng. *m.* $5. N. Y.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Civil Engineers. *m.* $10. New York
Transport. *w.* £1. 5*s.* London.
Western Electrician. *w.* $3. Chicago.
Western Railway Club, Pro. Chicago.
Wiener Bauindustrie Zeitung. *w.* 27 marks. Vienna.
Wisconsin Engineer. *qr.* $1.50. Madison, Wis.
Yale Scientific Monthly, The. *m.* $2.50 New Haven.
Zeitschrift für Lokomotivführer. *m.* 5 marks. Hannover.
Zeitschrift für Maschinenbau & Schlosserei, Berlin.
Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines. *w.* 53 marks. Vienna.
Zeitschrift des Vereines Deutscher Ingenieure. *w.* 32 marks. Berlin.
Zeitschrift für Elektrochemie. *s-m.* 16 marks. Halle, a. S.
Zeitschrift für Elektrotechnik. *s-m.* 16 marks. Halle a. S.
Zeitschrift für Instrumentenkunde. *m.* 20 marks. Berlin.

ARCHITECTURE AND BUILDING.

CONSTRUCTION AND DESIGN.

BATH-HOUSE.

Brookline's Model Bath-House. Illustrated detailed description. 2,300 w. Eng Rec—March 6, 1897. No. 11,459. 15 cts.

CHURCH.

The New Church of S. Matthew at Bâle. (Die Neue Protestantische Matthäus Kirche in Basel.) Description and perspective of Gothic church building for 1,200 sitters. 1,000 w. 1 plate. Schweizerische Bauzeitung—March 13, 1897. No. 11,742. 30 cts.

CONGRESSIONAL LIBRARY.

The Building for the Library of Congress. J. K. Orvis. A general account of the leading architectural characteristics, mentioning some of the most striking works of art which it contains. Ill. 11,000 w. Arch & Build—April 3, 1897. No. 12,026. 15 cts.

DOMES.

The Modern Dome. A. D. F. Hamlin. A study of dome design in both ancient and modern buildings; the value and beauty of this feature, with special reference to the dome of the new library of the university. 4,000 w. Sch of Mines Quar—Jan., 1897. No. 11,988. 45 cts.

EXPOSITION of 1900.

The New Palaces of the Champs-Elysées. (Les Nouveaux Palais des Champs-Elysées.) Plate and brief description of the new buildings being erected on the site of the former Palace of the Champs-Elysées. 500 w. and plate. La Revue Technique—March 10, 1897. No. 11,760 30 cts.

FALSE PERSPECTIVE.

Deliberate Deception in Ancient Buildings. G. A. T. Middleton. Comment on the discoveries of Prof. Goodyear and others, relating to curves in ancient buildings intended apparently to give impressions of greater length by intentionally exaggerated perspectives. 1,800 w.. Nineteenth Cent—March, 1897. No. 11,609. 45 cts.

FIRE Station.

Station for a Boston Fire Company. Illustrated description of new building on Warren street. 1,400 w. Eng Rec—March 20, 1897. No. 11,805. 15 cts.

FLOORS.

Origin and History of Hollow Tile Fire-Proof Floor Construction. Peter B. Wight. Part first gives the early history in the United States of the use of I beams, brick arches and other forms of floor construction which finally led to the use of hollow tile. Illustrated. 2,500 w. Br Build—March, 1897. Serial. 1st part. No. 11,940. 30 cts.

FOUNDATIONS.

The Conditions of Uniform Pressure in Foundations. (Ueber die Bedingungen einer gleichförmigen Druckvertheilung in den Fundamenten.) R. F. Mayer. A continuation of Prof. Mayer's interesting and valuable studies of the actual conditions existing in foundations of masonry piers. 2,000 w. Zeitschr d Oesterr Ing u Arch Ver—Feb. 19, 1897. No. 11,728. 30 cts.

The Distribution of Pressure in Irregular Foundations. (Druckvertheilung in gebrochenen Fundamentflächen.) A criticism by Prof. Spitzer, of Mélan's theory, together with a graphical demonstration of a method of determining the distribution of pressure, especially in arch piers. 2,000 w. Zeitschr d Oesterr Ing u Arch Ver—Feb. 12, 1897. No. 11,723. 30 cts.

Distribution of Pressure in Irregular Foundations. (Druckvertheilung in gebrochenen Fundamentflächen.) A reply by Prof Mélan to the strictures of Prof. Spitzer, with diagram further elucidating the subject. 1,000 w. Zeitschr d Oesterr Ing u Arch Ver—Feb. 26, 1897. No. 11,733. 30 cts.

FRANCE, Soc. of Civil Engineers.

The New House of the Society of Civil Engineers of France. (Das neue Vereinshaus der "Société des ingenieurs civils de France," in Paris.) Illustrated description of the fine new building of the French Civil Engineers. 1,500 w. Schweizerische Bauzeitung—Feb. 27, 1897. No. 11,738. 30 cts.

MASONRY.

Ancient and Modern Masonry. Brief accounts of various constructions, with illustrations. Ill. 900 w. Ill Car and Build—Feb. 26, 1897. No. 11,511. 30 cts.

MONIER Construction.

Computations for Monier Beams. (Berechnungen der Monier-Träger.) A discussion by Herr Rappaport of the combined béton and metal construction, showing the importance of considering very carefully the relative elasticity of the materials used. 2,500 w. Schweizerische Bauzeitung. Feb. 27, 1897. No. 11,739. 30 cts.

NIJNI-NOVGOROD.

The Nijni-Novgorod Exhibition. Illustrations and brief descriptions of water-tower and buildings constructed on Mr. Schuchof's patent principle; their characteristic feature is the absence of any kind of roof-truss or girder. 600 w. Eng Lond —March 19, 1897. No. 11,916. 30 cts.

ROOFING.

Roofing Tiles and Their Manufacture. C. W. Crawford. The manner of holding the tiles to the roof, their advantages and disadvantages, followed by a discussion which includes the paper of Mr. Bleininger

with the one presented. 7,500 w. Brick—March, 1897. No. 11,474. 15 cts.

STYLE.

Is a National Twentieth Century Style of Architecture Probable? Banister Fletcher. Report of a lecture given at the hall of the Carpenters' Company, London. Thinks design and planning must be a work of gradual development. 1,500 w. Arch Lond—March 19, 1897. No. 11,943. 30 cts.

SUNDAY School.

Sunday School Planning. A. F. Wickson. Points out the requirements of these buildings and gives plans. Read before the Toronto Chapter of Architects. 1,600 w. Can Arch—March, 1897. No. 11,836. 30 cts.

TALL Buildings.

Foundation Construction for Tall Buildings. Charles Sooysmith. Illustrated. Devoted principally to a description of the caisson method. 3,800 w. Eng Mag—April, 1897. No. 12,047. 30 cts.

THEATRES.

On Some American Theatre Designs. Editorial review of book on "The Planning and Construction of American Theatres," by William H. Birkmire, with criticisms of presented designs. 2,200 w. Builder—March 6, 1897. No. 11,640. 30 cts.

WORKMEN'S Houses.

The Vienna Society for Better Dwellings. (Der Verein für Arbeiterhäuser in Wien.) A review of the report of the Vienna society for improvement in workmen's houses, with illustrations of designs, with data as to cost of building and maintenance. 1,500 w. Zeitschr d Oesterr Ing u Arch Ver—Feb. 19, 1897. No. 11,726. 30 cts.

English Homes for Workingmen. Octavius Grant Wood. Illustrated description of the cottages at Port Sunlight and an account of the ideal conditions, demonstrating the possibility of bringing happiness and plenty to the employee and also prosperity to the proprietors. 1,500 w. In Arch—March, 1897. No. 11,655. 45 cts.

HEATING AND VENTILATION.

BOILERS.

Church Heated with Battery of Boilers. Describes the heating arrangements in use at St. Patrick's Church at Utica, N. Y. 1,000 w. Mas St Fit—March, 1897. No. 11,920. 15 cts.

CAPITOL.

Heating and Ventilation of the Pennsylvania State Capitol. Brief description, with engravings. The building has been destroyed by fire. 400 w. Heat and Ven—March 15, 1897. No. 11,821. 15 cts.

CHIMNEY.

A Chimney Trouble and the Cause of It. Frederick Dye. Describes a trouble called "syphonage" by those who know of it, that occurred in an English home. 1,400 w. Heat and Ven—March 15, 1897. No. 11,823. 15 cts.

CONVENTION.

The First Convention of Warming and Ventilating Engineers, Berlin, 1896. (Die I. Versammlung von Heizungs-und Lüftungs-Fachmännern in Berlin, 1896.) Containing a general report of the progress and present state of the art of warming and ventliation in Germany. 3,500 w. Zeitschr d Oesterr. Ing u Arch Ver—March 5, 1897. No. 11,735. 30 cts.

ENGINEERING.

Heating and Ventilating Engineering. Calls attention to the demands made on architects, and the growth of these two allied branches, demanding expert service. Also discusses the commissions paid architects and their need of being increased. 2,200 w. Am Arch—March 20, 1897. No. 11,840. 15 cts.

New Method of Heating and Ventilation. Charles Carroll Gilman read at meeting of Am. Soc. of Civ. Engs. Describes experiments based on the fact that air rarified by heating will cause a circulation in the rooms of a building. 1,100 w. Arch and Build—March 27, 1897. No. 11,895. 15 cts.

HEATING.

Improved Apparatus for Heating and Cooking by Electricity. (Noveaux Appareils de Chauffage et de Cuisine par l'Electricité.) Description of the simple and portable cooking and heating devices for use with electric current, now being made in Paris. 2,000 w. Le Génie Moderne. Feb. 15, 1897. No. 11,747. 45 cts.

Rules for Proportioning Furnace Systems. J. H. Kinealy. A study of the problem. Part first states the things necessary to determine and examines some of them. 1,800 w. Met Work—March 13, 1897. No. 11,562. 15 cts.

HOT WATER.

Hot Water Heating Without Fuel. Describes a system found possible in the vicinity of Boise, Idaho, where thermal waters were discovered at a depth of nearly 400 feet, and the water gushed to a height of 40 feet above the ground. 1,000 w. Met Work—March 20, 1897. No. 11,696. 15 cts.

RADIATORS.

Some Relations Between the Arrangement of Heating Surfaces in Radiators, the Velocity of the Air Passing Over Such Surfaces, and Their Efficiency. H. Eisert. An analysis of the results from tests and a study under stated conditions. 3,800 w. Heat and Ven—March 15, 1897. Serial, 1st part. No. 11,825. 15 cts.

SCHOOL Ventilation.

Ventilation of a Brooklyn (N. Y.) School. Ventilation is effected by forcing the air through the buildings by a

blower and out through a system of vent flues leading to a main ventilating shaft. 1,500 w. Eng Rec—March 20, 1897. No. 11,808. 15 cts.

STEAM Heating.

Defective Steam Heating Plants. W. H. Wakeman calls attention to some defects which cause steam plants used for heating purposes to work in an unsatisfactory manner. 1,400 w. Heat and Ven—March 15, 1897. No. 11,822. 15 cts.

LANDSCAPE GARDENING.

GARDEN.

Garden Design. Editorial comment on a recent article by Inigo Thomas. 1,400 w. Gar and For—March 31, 1897. No. 11,951. 15 cts.

PARKS.

Chicago's Lake Front Parks. An account of the improvements being made, at great expense, along the shore of Lake Michigan. 2,000 w. Harper's Wk—April 3, 1897. No. 11,947. 15 cts.

New York Zoological Park. William T. Hornaday. Brief account, with illustrations, of some of the noted zoological gardens of Europe, with statement of New York's prospect of a fine zoological park, and some particulars relating to the proposed plan. 2,700 w. Harper's Wk—March 20, 1897. No. 11,610. 15 cts.

TREES.

Roadside Trees. Editorial protest against the cutting down of trees in rural roads. 1,100 w. Gar and For—March 24, 1897. No. 11,866. 15 cts.

PLUMBING AND GAS FITTING.

BATH-House.

Plumbing a Public Bath House. Describes the plumbing of a new building in Newark, N. J. Illustrated. 1,700 w. Met Work—March 27, 1897. No. 11,894. 15 cts.

BATHS.

St. Marylebone New Baths and Wash-Houses. Description of the arrangement of the new baths and wash-houses recently opened. 1,800 w. Arch Lond—March 12, 1897. No. 11,815. 30 cts.

DRAINAGE.

Notes on Drainage and Sanitation. From the Building World. Calls attention to points of importance in the construction of drains and the renewing of a drainage system. Illustrated. 1,400 w. Dom Engng—March, 1897. No. 11,801. 30 cts.

The Ventilation of House Drains. Richard Horton. Read before the Inst. of San Engs, England. States the usually accepted theory of ventilation, compares it with the facts and gives a few experiments and their results. 1,400 w. San Rec—March 5, 1897. Serial. 1st part. No. 11,628. 30 cts.

SANITATION.

Progress in Household Sanitation. From the Albany Argus. Reviews recent advancement in sanitary plumbing. 1,100 w. San Plumb—March 15, 1897. No. 11,630. 15 cts.

MISCELLANY.

ARCHITECT.

The Architect and the Public. W. H. Bidlake. Read before the Architectural Assn. of London. Discusses how to bring about a more harmonious working for their mutual help. Followed by discussion. 9,500 w. Builder—Feb. 27, 1897. No. 11,526. 30 cts.

ART.

Art and Architecture. Frederick Baumann. Considers the two questions, Is Architecture a Living Art? and Can Architecture Again Become a Living Art? Historical review of the development, with features of the architecture of different ancient nations, finally answering the first question negatively. The educational requirements and paths leading to the affirmative answer of the second question are discussed. 7,500 w. Stone—March, 1897. No. 11,658. 30 cts.

BEAMS.

See same title under Civil Engineering—Miscellany.

BRICKS.

Glazed Bricks. Discusses the advantages and disadvantages of salt-glazed and enamelled bricks, describes their manufacture and method of testing. 1,500 w. Builder—Feb. 27, 1897. No. 11,525. 30 cts.

CARDIFF.

The Architecture of Our Large Provincial Towns. Cardiff. Historical account and illustrated description of architectural points of interest and of the important buildings. 5,800 w. Builder—March 13, 1897. No. 11,810. 30 cts.

GESSO.

Gesso. Matthew Webb. Read before the Applied Art Section, Society of Arts. Explains the distinction between gesso and stucco and touches also on stucco works, the composition of gesso and treatment. 3,000 w. Arch, Lond—March 5, 1897. Serial. 1st part. No. 11,657. 30 cts.

GRANITE, Tests of.

Experimental Investigations Upon Granite. (Untersuchungen von Granit.) C. Bach. A most valuable series of experiments upon the strength and elasticity of granite, with tabulated and graphical records; also an extension of the principles developed to other materials of construction. 10,000 w. Zeitschr d ver deutscher Ing—Feb. 27, 1897. No. 11,711. 30 cts.

GREECE.

Greek Sculpture and Greek Legend. F. S. Granger. Read before the Architectural Assn. Discusses the sculpture of the Acropolis of Athens; the legend of

Athena, the divine protector of the Athenians, and the architecture. 5,200 w. Arch, Lond—March 12, 1897. No. 11,816. 30 cts.

HERALDRY.

Heraldry in English Mediaeval Architecture. W. H. St. John Hope. Abstract of a paper read before the Roy. Inst. of Brit. Archts. Confined to the period between 1216 and 1547. Followed by brief discussion. 1,600 w. Arch, Lond—March 19, 1897. No. 11,942. 30 cts.

LANDSLIDE.

The Fall of the Gumpendorf Slaughter-House in Vienna. (Der Einsturz in Gumpendorfer Schlachthause in Wien.) Illustrated description of the wrecking of a large building by the slipping of the foundation of a retaining wall. 1,000 w. Zeitschr des Oesterr Ing u Arch Ver—Feb. 26, 1897. No. 11,732. 30 cts.

LIBRARY.

The National Library Notes on a lecture by Mr. Barnard R. Green. Ill. 2,500 w. In Arch—March, 1897. No. 11,656. 45 cts.

NEW YORK.

The Sky-Line of New York, 1881-1897. Montgomery Schuyler. Comments on the changes wrought in the appearance of the city as viewed from the harbor, with illustrations giving the view in 1881 and again in 1897. 1,300 w. Harper's Wk—March 20, 1897. No. 11,611. 15 cts.

PARIS.

Paris the Magnificent. H. H. Ragan. Describes the striking features of the city, giving illustrations of the beautiful architecture and streets. 3,000 w. Chau. April, 1897. No. 11,870. 30 cts.

ROOFING.

Roofing Tiles in the Fatherland. Albert V. Bleininger. Considers the process of the manufacture of these tiles, and their classification according to patterns. 3,500 w. Brick—March, 1897. No. 11,473. 15 cts.

SCHMIDT MONUMENT.

Dedication of the Monument to Friedrich Schmidt in Vienna. (Das Friedrich Schmidt Denkmal in Wien.) An account of the ceremonies of the dedication of the portrait statue of the late eminent architect of Vienna with an excellent illustration. Zeitschr d Oesterr Ing u Arch Ver—Feb. 19, 1897. No. 11,729. 30 cts.

STAINED GLASS.

The Art of Stained Glass. Pauline King. The gradual progress, waning and new life of stained glass; the artists most noted in this work, and its success in this country. 1,800 w. Chau—April, 1897. No. 11,872. 30 cts.

TIMBER.

See same title under Civil Engineering—Miscellany.

TRAINING.

On the Probable Influence of the Technical Education Movement Upon the Architect and His Work. Frank Caws. Read at meeting of the Northern Arch Assn. Short discussion. 5600 w. Jour Roy Inst of Brit Archs—March 4, 1897. No. 11,848. 30 cts.

TRAINING.

The Educational Training of Architects. Leopold Eidlitz. Reviews the past practice in the training of architects and its effects. The influence of the science of mechanics on architecture; the influence of history. Discussion follows. 7,000 w. Jour Roy Inst of Brit Archs—March 4, 1897. No. 11,847. 30 cts.

CIVIL ENGINEERING.

BRIDGES.

BRIDGES.

See Standard Specifications for Metal Bridges, Boston & Maine R. R., under Railroad Affairs. Maintenance of Way and Structures.

BRIDGE Extension.

Extension of Skinner Street Bridge. Description and illustration of work made necessary by the extension of the terminal station of the Great Eastern Railway. 2,000 w. Eng Lond—Feb. 26, 1897. No. 11,515. 30 cts.

CANTILEVER.

The Francis-Joseph Bridge at Budapest. (Die Franz-Josefs-Brücke in Budapest.) Illustrated description of the new steel cantilever bridge over the Danube at Budapest. The main clear span is 674 feet, the side spans 260 feet each. 3,500 w. Zeischr d Oesterr Ing u Arch Ver—Feb. 26, 1897. No. 11,731. 15 cts.

DRAWBRIDGE.

The Hydraulic Rolling Bridge of the Port of Cherbourg. (Pont Rouland Hydraulique du Port de Cherbourg.) This is a bridge spanning the passage between two of the basins of the Cherbourg docks and is arranged to be lifted and drawn back by hydraulic power; span 98 feet. 2,500 w. 1 Plate. La Revue Technique—Feb. 25, 1897. No. 11,751. 30 cts.

DULUTH-Superior.

The Duluth-Superior Bridge. Elevation, plan, cross-section, and general description of an important bridge nearly completed, connecting Rice's Point, Duluth, with Connor's Point, Superior. 800 w. R R Gaz—March 12, 1897. No. 11,552. 15 cts.

FOUNDATIONS.

Foundations for Masonry. Deals principally with the setting out of foundations for bridges and the care necessary.

Ill. 1,400 w. Ill Car & Build—Feb 26, 1897. No. 11,510. 30 cts.

GIRDERS.

Contribution to the Question of the Cross Section of Continuous Plate Girders. (Beitrag zur Frage der Querschnittsermittlung Kontinuilicher Blechbalken. A Meves.) A graphical examination of a method by which the greatest bending moment, and consequent section, may be obtained with little labor for any given conditions. 2,500 w. Zeitschr d ver deutscher Ing—Feb. 6, 1897. No. 11,703. 30 cts.

New Formulas for Finding the Economical Height of Plate Girders. Henry Szlapka. Formulas given are simpler than those generally used and claimed to be theoretically exact within the limits of the assumption. 500 w. Eng Rec—March 27, 1897. No. 11,900. 15 cts.

LONG Span.

Long-Span Bridges for Great Cities. O. F. Nichols. A paper presented at the meeting of the Dept. of Engng. of the Brooklyn Inst. of Arts and Sciences, having special reference to projects for crossing the East River, N. Y. 5,000 w. Eng Rec—March 13, 1897. No. 11,638. 15 cts.

MASONRY.

Masonry for Bridges. C. E. Fowler. Illustrated examples of noted bridges are given with a few suggestions. 800 w. Stone—March, 1897. No. 11,660. 30 cts.

MASONRY Arch.

Brick Arch with Stone Facing at the Entrance to Cornell University Campus, Ithaca, N. Y. Illustrated description of arch built in place of old cast-iron bridge at the entrance to the campus. 900 w. Eng News—March 11, 1897. No. 11,550. 15 cts.

MOMENT Table.

An Improved Moment Table. W. C. Armstrong. A table for computing moments and shears in bridge trusses from concentrated loads, presenting new features aiming to reduce the arithmetical work to the least possible limit consistent with the desired accuracy. 1,200 w. Eng News—March 11, 1897. No. 11,549. 15 cts.

NEW ORLEANS.

The Proposed Mississippi River Bridge at New Orleans. Brief description of design, the special features of which are a span of 1,000 ft. and the character of the foundation material. 700 w. Eng News—April 1, 1897. No. 12,014. 15 cts.

NIAGARA.

New Steel Arch Bridge for Trolley Line Across the Niagara Gorge. Orrin E. Dunlap. Describes bridge in course of construction which will afford the first trolley car connection between the Dominion of Canada and the United States. 700 w. W Elec—April 3, 1897. No. 12,025. 15 cts.

STEEL Arch.

Recent Bridge Competitions. (Neue Brückenwettbewerbe. R. Krohn.) A discussion by the engineer of the Gutehoffnungshütte, of recent designs for steel arch bridges of spans of 400 to 640 feet, including the bridges for Bonn, Bern, and Düsseldorf. 6,000 w. Zeitschr d Ver deutscher Ing—Feb. 13, 1897. No. 11,706. 15 cts.

STRAINS.

Measures the Bridge Strain. An account of an instrument so sensitive as to accurately measure the strain caused by the footfall of a pedestrian crossing Brooklyn Bridge. 1,100 w. Sci Am Sup—March 20, 1897. No. 11,670. 15 cts.

SUSPENSION Bridge.

The Suspension Bridge Over the Ohio River at Rochester, Pa. E. K. Morse. Illustrated description of a bridge with a channel span of 800 ft., with some opinions of the writer on the construction of suspension bridges. 3,000 w. Eng News—April 1, 1897. No. 12,010. 15 cts.

Suspension Bridge Over the Ohio River at East Liverpool, O. Hermann Laub. Illustrated description of bridge for highway and electric railway traffic, of the stiffened suspension type. 1,500 w. Eng News—April 1, 1897. No. 12,012. 15 cts.

CANALS, RIVERS AND HARBORS.

CAISSON.

Movable Pneumatic Caisson for Submarine Rock Excavation. From Revue Technique. Description of an apparatus installed by the Prussian Government, near Bingen, for the removal of the rocks in the river Rhine. 600 w. Eng Rec—March 6, 1897. No. 11,455. 15 cts.

The Caisson at North Pier-Head, Madras Harbor. Robert William Thompson. Description, with illustration, of a difficult piece of work. 2,400 w. Ind & East Eng—Jan. 30, 1897. No. 11,465. 45 cts.

CANAL.

The Dismal Swamp (North Carolina) Canal. Croatan. Letter to the editor calling attention to errors in an article published in this same paper in the issue of March 5. 1,100 w. R R Gaz—March 19, 1897. No. 11,691. 15 cts.

DAM.

See Electrical Engineering—Power, and Civil Engineering—Miscellany.

GREAT LAKES.

Raising the Levels of the Great Lakes. B. H. Muehle. Abstract from the advance proofs of a paper presented to the Michigan Engng. Soc. A study of the effect the construction of deep water channels to the sea will have on the levels of the lakes, with a discussion of projects for artificially raising the lakes. 1,700 w. Eng News—March 18, 1897. No. 11,789. 15 cts.

LOCKS.

Cascade Locks. Edw. K. Bishop. Interesting description of locks on the Columbia River, rivalling those of Sault Ste.

Marie in size, and affecting a territory about double the area of New York State. 2,300 w. Sci Am—March 13, 1897. No. 11,533. 15 cts.

MISSISSIPPI Improvement.

The Problem of Deep Water Navigation Through the Passes from the Mississippi River to the Gulf of Mexico. J. A. Ockerson. An account of the character of the passes and the work done on them, with the questions that must be considered in the selection of a proper site for carrying on successful works of channel improvement. Maps. 4,000 w. Jour Assn of Engng Soc—Feb., 1897. No. 11,891. 30 cts.

NEW YORK.

See New York Harbor, under Marine Engineering—Miscellany.

NICARAGUA Canal.

A Spanish View of the Nicaragua Canal. José Guitiérrez Sobral. States briefly the three proposed routes and the difficulties to be met; then discusses the value of a canal cutting the isthmus, and its importance in a military sense. 3,500 w. N Am Rev—April, 1897. No. 11,977 45 cts.

PROPULSION.

See Propellers and Propulsion under Marine Engineering.

RIVER IMPROVEMENT.

The Correction of the Flon and Its Affluents at Lausanne. (Correction du Flon Lausannois et de ses Affluents.) An illustrated account of the improvements of a mountain torrent which had been a constant source of danger from sudden inundations. Gives a good idea of Swiss hydraulic problems. 4,500 w. La Revue Technique. March 10, 1897. No. 11,756. 30 cts.

IRRIGATION.

IRRIGATION.

A Few Hints to Students of Irrigation Engineering. A. M. Ryon. The work in this field that will be required in the future, and the importance that the irrigation engineer should understand the laws and business side of the undertaking. 2,600 w. Sch of Mines Quar—Jan., 1897. No. 11,992. 45 cts.

WATER Supplies.

Water Supplies in Southern California. J. L. Van Ornum. A consideration of the physical characteristics of this region, with a study from personal investigations made eighteen months ago in the San Gabriel and San Bernardino Valleys. The chief mode of development is by tunnelling, though it contains examples of all important methods. 5,500 w. Jour Assn of Engng Soc—Feb., 1897. No. 11,893. 30 cts.

MISCELLANY.

BEAMS.

The Efficiency of Built-Up Wooden Beams. Edgar Kidwell. Summary of results obtained from a series of tests of such beams. Ill. 1,500 w. Eng News—March 11, 1897. No. 11,546. 15 cts.

CEMENT.

European Portland Cement Industry. Frederick H. Lewis. Notes of travel. Part first refers to the works at Grays, Essex, and the Francis works at Cliffe. 1,600 w. Eng Rec—March 13, 1897. No. 11,637. 15 cts.

Notes on the Use and Testing of Hydraulic Cements. H. P. Boardman. These notes are the result of nearly two years' experience in the cement testing laboratory of the Sanitary District of Chicago. Effects of varying proportions of water, testing, machine mixing, &c., are treated in part 1st. 2,700 w. Wis Eng—Jan., 1897. No. 11,855. 45 cts.

Methods of Cement Testing. Replies to a series of questions sent to civil engineers, chemists and others. 3,400 w. Munic Engng—April, 1897. No. 11,997. 30 cts.

CIVIL Engineers' Society.

Homes of the Engineers. An illustration of the new house of the Institution of Civil Engineers in London, with a reference to the work which is being carried on within its walls, and brief history of the society. 2,500 w. Ir & Coal Trds Rev—March 12, 1897. No. 11,852. 30 cts.

COMPENSATION.

Engineering Compensation. M. S. Parker. Brief statement of facts bearing upon the remuneration of civil engineers, and claiming that they are not compensated as highly as in other professional employments, nor as well in the United States as in England. 2,000 w. Jour Assn of Engng Soc—Feb., 1897. No. 11,890. 30 cts.

DAM.

The Proposed Steel-Faced Concrete Arch Dam, Ogden, Utah. Bids were called for on three distinct plans, which are illustrated and described. 1,800 w. Eng Rec—March 6, 1897. No. 11,454. 15 cts.

PILE Screwing.

A New Hydraulic Pile-Screwing Plant. Illustrated description. 600 w. Ind Engng—Feb. 27, 1897. No. 11,950. 45 cts.

ROADS.

Recent Legislation on Improved Roads. J. L. Van Ornum. A digest of road legislation in the United States, with editorial comment. 4,500 w. Eng News—March 25, 1897. No. 11,877. 15 cts.

TIMBER Preservation.

The Preservation of Structural Timber. John D. Isaacs. Reprinted from the Thirteenth Report of the State Mineralogist of California. Processes tried and abandoned, with a description of the practically successful processes in use, and those useful under stated conditions. 4,000 w. Eng News—March 11, 1897. No. 11,548. 15 cts.

TUNNEL.
An Irish Channel Tunnel. J. Ferguson Walker. A collection of the main facts of the history of proposed railway communication between Great Britain and Ireland, with some suggestions as to the practical realization of the scheme. 7,800 w. Contemporary Rev—March, 1897. No. 11,644. 45 cts.

WATERPROOF Cements.
Practical Points About Waterproof Cements. (Praktische Erfahrungen über die Herstellung wasserdichte Kitte.) A discussion, with many practical recipes for cements, glues, luting, &c., &c., which will resist the action of moisture. 2,500 w. Glaser's Annalen—March 1, 1897. No. 11,720. 45 cts.

ECONOMICS AND INDUSTRY.

COMMERCE AND TRADE.

CHINA.
China: Its Resources, Industries and Markets, with Special Reference to British Trade. General discussion of the position of this country in relation to trade, with information relating to products, communication, tariff, labor, resources, &c. 10,800 w. Ir & Coal Trd Rev—Feb. 26, 1897. No. 11,561. 30 cts.

ELECTRIC Machinery.
Foreign Duties on Electric Machinery and Lamps. A statement showing the rates of import duty leviable on dynamo-electric machinery and electric lamps in the principal European countries and India. 1,500 w. Cons Repts—March, 1897. No. 11,873. 45 cts.

EXPORT Trade.
The Significance of Our Expanding Export Trade. Thomas A. Eddy. Showing the dependence of export interests upon international banking facilities, swift and regular shipping facilities, and the adaptation of production to foreign demands. 4,100 w. Eng Mag—April, 1897. No. 12,045. 30 cts.

FAILURES.
The Decreasing Commercial Death Rate. An improvement of 11 per cent. in the number of business failures compared with the first quarter of 1896. 900 w. Bradstreet's—April 5, 1897. No. 12,008. 15 cts.

FOREIGN Trade.
Foreign Trade of Argentina, Uruguay and Brazil. Results of investigations conducted by a commission organized by National Assn. of Manufacturers of the U. S. A. The object is to give practical knowledge of the resources of these countries and to indicate means by which trade between these nations and the United States could be enlarged. Maps. 33,000 w. Circ of Nat Assn of Mfrs—No. 12. No. 12,041. 45 cts.

JAPAN.
Commercial Museum in Japan. The rules and regulations of the Osaka Commercial Museum, the purpose of which is to afford a central place for the exhibition of the productions of native and foreign producers. 3,800 w. Cons Repts—March, 1897. No. 11,875. 45 cts.

NAVIGATION Laws.
Protective Navigation Laws. Remarks on the upbuilding of our merchant marine and the bright outlook for our shipping. 2,000 w. Gunton's Mag—April, 1897. No. 12,004. 30 cts.

TARIFF.
Need of Integrity in Tariff Discussion. Discusses the subject as presented by different journals and from different points of view. 2,500 w. Gunton's Mag—April, 1897. No. 12,003. 30 cts.

New Customs Tariff of Barbados. List of import duties to be levied during the period from Jan. 1, 1892, to Dec. 31, 1897. 1,600 w. Bd of Trd Jour—March, 1897. No. 12,042. 30 cts.

Queensland Customs Tariff. A list of articles exempt from duty on importation into the colony, with the dates from which such exemption takes effect. 3,400 w. Bd of Trd Jour—March, 1897. No. 12,043. 30 cts.

The Dingley Tariff Bill. The metal schedule of the new Tariff bill introduced by the Ways and Means Committee of the United States Congress, with editorial comment. 7,800 w. Ir Age—March 18, 1897. No. 11,680. 15 cts.

Tariff Changes and Customs Regulations. Russia, Netherlands, Netherlands-Curacoa, Netherlands-Dutch Guiana, France, France-Tunis, France-Ivory Coast, Portugal, Portugal-Southeast Africa, Italy, Greece, Turkey, United States, Brazil, Bolivia, St. Lucia, St. Vincent, Victoria, West Australia. 3,700 w. Bd of Trd Jour—March, 1897. No. 12,044. 30 cts.

TRADE.
Pushing Our Trade Abroad. A. F. Tennille. Discusses the methods adopted by American manufacturers and compares them with Germany, and suggests the way to remedy. 1,100 w. Elec—March 31, 1897. No. 11,978. 15 cts.

CURRENCY AND FINANCE.

CURRENCY.
How Not to Reform the Currency. A discussion of ideas of Austin W. Wright, as expressed in an article in "Free Banking, &c.," in Electrical Engineering, Aug. 1896. The writer thinks the situation in the United States requires constructive

legislation, obliging all banks to come under a general banking act. 2,400 w. Gunton's Mag—March, 1897. No. 11,488. 30 cts.

CHINA.

Chinese Finance. A short sketch of the main points of an interesting article by Mr. Consul Jamieson, of Shanghai, bearing on the revenue and expenditure of the empire. 1,800 w. Engng—March 12, 1897. No. 11,830. 30 cts.

CURRENCY.

The First Step in Currency Reform. Henry J. Ford. A discussion of the situation in the United States, urging banking reform before the retirement of treasury notes, and criticism of the resolutions of the Indianapolis Monetary Convention. 1,800 w. Bankers' Mag N Y—March, 1897. No. 11,645. 45 cts.

FINANCE.

Growth of Sound Financial Opinion. Reviews the history of financial opinion in the United States, shows encouraging signs of a general growth of uniform opinion on the essential principles of finance, and gives the suggestions for reform as presented in the N. Y. Journal of Commerce. 3,800 w. Gunton's Mag—March, 1897. No. 11,486. 30 cts.

FINANCIAL Problem.

Arbitration the Only Solution of the Financial Problem. Allen Ripley Foote. Reasons for constituting a United States currency commission are given and the various phases of the problem discussed. 4,200 w. Forum—April, 1897. No. 11,945. 30 cts.

MONEY.

Money Without Law. Carlyle McKinley. Discusses means of adjusting the differences between the advocates and opponents of free coinage of silver. Suggests the adoption of gold and silver pieces of uniform weight and quality, as the only thing necessary to establish a perfect system of international money for all nations that adopt it. 3,200 w. Bankers' Mag N Y—March, 1897. No. 11,646. 45 cts.

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A Pivotal Movement in Finance. A discussion of the Lake Shore Railway refunding plan and its effect. 1,000 w. Bradstreet's—March 13, 1897. No. 11,564. 15 cts.

GOVERNMENT CONTROL.

ANTI-TRUST Law.

Railroad Agreements Under the Anti-Trust Law. Discusses the decision in the action brought by the United States Government against the Trans-Missouri Freight Assn. Also some of the effects of the decision. 2,200 w. Bradstreet's—March 27, 1897. No. 11,896. 15 cts.

TRUSTS.

Investigation of the "Rubber Trust." Comments on the investigations of the United States Rubber Co. 2,500 w. Ind Rub Wld—March 10, 1897. No. 11,650. 45 cts.

The Lexow Anti-Trust Report. Comment on the report of the New York State Investigating Committee, reviewing the work and what was accomplished. 2,500 w. Gunton's Mag—April, 1897. No. 12,006. 30 cts.

Views of an Anti-Monopolist on Trusts. A statement of Mr. Thurber's views as presented to the Lexow Committee in New York. 1,600 w. Gunton's Mag—April, 1897. No. 12,007. 30 cts.

LABOR.

EIGHT-Hour Day.

How to Attain the Eight-Hour Day. Rev. Jesse H. Jones. Suggestions for the attainment of this end and arguments showing that business will be as profitable as on the ten-hour system. 2,000 w. Gunton's Mag—March, 1897. No. 11,487. 30 cts.

JAPAN.

Conditions of Labor in Japan. Fusataro Takano. Presents the life conditions of the typical classes of Tokyo workers who represent Japanese laborers of the whole country in many respects. 2,800 w. Gunton's Mag—April, 1897. No. 12,005. 30 cts.

PADRONE System.

The Padrone System and Padrone Banks. John Koren. Describes the system as practised in the United States some thirty years ago, which no longer exists, and what is termed the padrone system at the present time, with other matters relating to Italian labor; also the peculiar system of banking in vogue among the Italians of this country. 8,000 w. Bul of Dept of Labor—March, 1897. No. 11,647. 45 cts.

STRIKE.

An English Railroad Strike. W. M. Acworth. A brief account of the recent strike on the Northeastern Railway of England. 1,200 w. R R Gaz—March 26, 1897. No. 11,889. 15 cts.

The Collapse of the Northeastern Strike. Short account of the trouble and its settlement. 1,800 w. Trans—March 5, 1897. No. 11,605. 30 cts.

TRADE UNIONS.

Organized Labor Abroad. Evidence of the progress of trade-unionism abroad. 1,600 w. Gunton's Mag—March, 1897. No. 11,489. 30 cts.

The Engineers' Dispute. Editorial discussion of labor troubles in England, with letters sent by employers to the Amalgamated Soc. 2,800 w. Engng—March 5, 1897. No. 11,598. 30 cts.

WORKMEN'S Houses.

See same title under Architecture and Building—Construction and Design.

MISCELLANY.

CANADA.

The Progress of Canada During the Six-

ty Years of Her Majesty's Reign. J. G. Colmer. A description of Canada as it was, of some of the prominent events in the last sixty years, and Canada as it is to-day. Short discussion follows. 10,500 w. Jour Soc of Arts—March 5, 1897. No. 11,590. 30 cts.

CHINA.

See same title under Electrical Engineering—Miscellany.

JAPAN.

Railroad and Industrial Improvements in Japan. Calls attention to the efforts made by this government to investigate the methods of railroads in the United States and Europe, and to make themselves masters of allied industries. 900 w. No. 11,885. 15 cts.

LUMBER Industry.

Modern Logging in the Northwestern States. Edward K. Bishop. Describing the improved methods of yarding and hauling logs in an Oregon logging camp. Ill. 3,200 w. Eng Mag—April, 1897. No. 12,051. 30 cts.

NETHERLANDS.

The Dutch Society for General Welfare. J. Howard Gore. A study of the work accomplished by this society in Amsterdam, whose purpose is to "advance general prosperity and to strive for the promotion of the intellectual, moral and social condition of the people, especially by fostering education, by ennobling their concept of life, by increasing the earning capacity of the wage earner and by enabling him to better enjoy the fruits of his labor." 9,000 w. Bul of Dept of Labor—March, 1897. No. 11,648. 45 cts.

NICARAGUA Canal.

See Civil Engineering, Canals, Rivers and Harbors.

PROSPERITY.

What Will Bring Prosperity? Charles Stewart Smith and Francis B. Thurber. Mr. Smith recommends fair play to honest industry, whether represented by private workers or organized capital, and the dispelling of all doubt as to the circulating medium of the country (the United States). Mr. Thurber suggests six important steps that should be taken, the first being the settlement of finances. 2,800 w. N Am Rev—April, 1897. No. 11,976. 45 cts.

ELECTRICAL ENGINEERING.

ELECTRO-CHEMISTRY.

BLEACHING.

The Sulphite and Electric Works at Hallein. (Die Sulphit und Elektrischen Anlagen in Hallein.) An account of the new paper pulp works at Hallein, near Salzburg, in which the bleaching is performed by Dr. Kellner's process of sulphite and electric current. 1,500 w. Elektrochemische Zeitschr—Feb., 1897. No. 11,771. 45 cts.

CARBON Element.

Experiments Upon the Carbon Element. (Untersuchungen über die Vorgänge im Kohle-Element.) Experiments in the production of electricity by the solution of carbon in melted caustic potash, with reference to the researches of Dr. Jacques and Mr. Reed, made in the laboratory of the Hagen Accumulator Works. 3,000 w. and many diagrams. Zeitschr für Elektrochemie—Feb. 20, 1897. No. 11,768. 30 cts.

FURNACES.

Electric Furnaces. J. Warren. Description of some of the most notable furnaces constructed with a view to transforming ordinary carbon into its denser modifications. Ill. 2,000 w. Elec, Lond—March 12, 1897. Serial. 1st part. No. 11,800. 30 cts.

A Simple Form of Electric Furnace. (Ueber eine geeignete Form des Elektrischen Ofens.) A small furnace, suitable for the production of calcium carbide or carborundum, made of solid blocks of carbon. 1,500 w. Zeitschr für Elektrochemie—Feb. 5, 1897. No. 11,766. 30 cts.

METALLURGY.

Metallurgical Applications of Electric Heating. H. Poisson, in Revue Industrielle. Describes processes and furnaces. Ill. 2,200 w. Sci Am Sup—March 20, 1897. No. 11,671. 15 cts.

LIGHTING.

ALTERNATING Currents.

Alternating Current Working. H. E. Raymond. Suggestions intended to aid the inexperienced in the practice of alternating-current transmission. 1,600 w. Am Elect'n—March, 1897. No. 11,780. 15 cts.

ARC.

Curious Freak of a Voltaic Arc. Brief illustrated description of irregular performance, and the cause and remedy. 500 w. W Elec—March 27, 1897. No. 11,901. 15 cts.

ARC Lamps.

Regulation of Arc Lamps. Calls attention to the work that is being done in Europe. Three distinct types of arc lamp are presented; the Eck arc lamp, Klosterman lamp "la moderne" and Barriére table lamp. Ill. 2,200 w. W Elec—March 20, 1897. No. 11,797. 15 cts.

Whistling Arcs—A Case of Electrostatic Induction and the Remedy. Foree Bain. An account of a strange phenomenon and the experiments made to determine the cause, with the remedy adopted. 3,300 w. W Elec—March 6, 1897. No. 11,468. 15 cts.

CAR LIGHTING.

The Electric Lighting of the Austrian Railway Post-Offices. (Die Elektrische

Beleuchtung von Eisenbahn Postwagen in Oesterreich.) Illustrated description of the system of incandescent lamps and storage batteries used in the railway post-office cars in Austria. 2,500 w. Elektrotechnische Zeitschr—March 4, 1897. No. 11,765. 30 cts.

COAST Defense.

The Electric Light for Coast Defense. M. A. Boyd. Synopsis of a lecture as given in an English journal, giving views held abroad on this subject after practical tests. 900 w. W Elec—March 13, 1897. No. 11,581. 15 cts.

COLD Light.

A Cold Light. A brief account of experiments now being carried out in Europe by Puluj. 700 w. Bos Jour of Com—March 27, 1897. No. 11,921. 15 cts.

ELECTRIC Light.

See "Electric Light," under Marine Engineering.

DECORATIVE Lighting.

The Electrical Features of the Inaugural Ball. Louis Denton Bliss. Illustrated description of the electrical decorations. 2,000 w. Am Elect'n—March, 1897. No. 11,778. 15 cts.

DISTRIBUTION.

Principles of Electrical Distribution. Francis B. Crocker. Studied chiefly from the development in electric lighting. Part first deals with the series system of distribution. 6,000 w. Sch of Mines Quar—Jan., 1897. Serial. 1st part. No. 11,987. 45 cts.

FAULTS.

A Direct-Reading Fault Localizer. F. Charles Raphael. Illustrated description of instrument to facilitate the localization of faults in light and power cables. 1,000 w. Elect'n—March 12, 1897. No. 11,849. 30 cts.

FIRES.

The Prevention of Fires Due to Leakage of Electricity. Frederick Bathurst. The Fothergill prize essay. Gives a review of the present methods of wiring and reasons for advocating insulating tubing. Discussion follows. 7,500 w. Jour Soc of Arts—March 12, 1897. No. 11,835. 30 cts.

HIGH-VOLTAGE.

The 1897 High-Voltage Lamp. The progress made during the past year. Ill. 1,100 w. Elect'n—March 5, 1897. No. 11,653. 30 cts.

INCANDESCENT Lamps.

Exhausting Lamps by the "Chemical" Method at the Edison Lamp Works. Describes the method used and states its advantages. Ill. 1,000 w. Elec Eng—March 31, 1897. No. 11,954. 15 cts.

Street Lighting in England by Incandescent Lamps. A few facts and opinions on the advantages and disadvantages of the system, from experts and practical men of England. 2,100 w. Elec Wld—March 20, 1897. No. 11,813. 15 cts.

The Selection of Incandescent Lamps for Use in Trolley Cars. W. Sonneberg. Points out the necessity for discrimination. 1,100 w. Am Elect'n—March, 1897. No. 11,781. 15 cts.

INSULATION and Resistance.

Investigations Upon Electric Plants. (Untersuchung von Elektrischen Anlagen.) A brief outline of the methods of measuring the insulation and resistance of electric lighting systems. 1,000 w. Glaser's Annalen—Feb. 15, 1897. No. 11,717. 45 cts.

On the Measurement of the Insulation Resistance of Continuous Current Three-Wire Systems While at Work. Edwin J. Houston and A. E. Kennelly. A response to criticism of method of the writers by Maurice Travailleur in L'Eclairage Electrique. 1,500 w. Elec Wld—March 6, 1897. No. 11,499. 15 cts.

ISOLATED Plant.

The Isolated Plant at the Hillside House, Scranton, Pa. H. B. Coho. Illustrated detailed description of the interesting features of this plant. 1,800 w. Elec Eng—March 31, 1897. No. 11,955. 15 cts.

LAMP Testing.

Lamp Testing Bureau Proposed for the National Electric Light Association. President Nichol's plan for establishing a lamp testing-bureau. 1,800 w. Elec Eng—March 10, 1897. No. 11,498. 15 cts.

LIGHTING.

Electric Lighting. Henry Stooke. Part first consists of an introduction of subject and definition of arc lamp. Ill. 900 w. Ill Car and Build—Feb. 26, 1897. Serial, 1st part. No. 11,509. 30 cts.

MUNICIPAL Lighting.

Municipal Lighting Reports. George S. Thayer. Calls attention to some reasons why municipal ownership does not pay, and quotes reports from various places. 1,500 w. Elec Eng—March 24, 1897. No. 11,864. 15 cts.

Notes on the Electric Lighting of Fort William. Illustrated description of the installation of a town in Scotland, the first in that country to be lighted by means of water power. 1,300 w. Elec Rev, Lond—March 5, 1897. No. 11,654. 30 cts.

The Municipal Electric Lighting Plant at Frankfort-on-the-Main. Describes the design of the station, the distributing system and the operation of the plant. Ill. 1,900 w. Eng Rec—March 20, 1897. No. 11,807. 15 cts.

PHOTOMETRY.

The Question of Photometric Units. (Zur Frage der photometrischen Einheiten.) An argument for the establishment of international units of strength, brill-

iancy, efficiency, &c., of light, similar to the electrical units already in use. 3,500 w. Elektrotechnische Zeitschrift. Feb. 18, 1897. No. 11,761. 15 cts.

VACUUM TUBE.

Vacuum Tube Lighting. M. A. Edson. Read before the Chicago Electrical Assn. Discusses the various sources of artificial illumination and the problem of reflection and diffusion of light, with a review of the work done in vacuum tube lighting. 2,800 w. W Elec—March 6, 1897. No. 11,469. 15 cts.

POWER.

ALTERNATORS.

The Maximum Output of Alternators. Dugald C. Jackson. Gives theoretical formulas which apply with a considerable degree of accuracy to the only machine with which the writer had an opportunity to experiment. 6,500 w. Elec Wld—March 20, 1897. No. 11,812. 15 cts.

DYNAMO.

A New Three-Wire Dynamo. T. R. D. Kenny. A discussion of the advantages of the machine. 1,600 w. Elec Rev, Lond—Feb. 26, 1897. No. 11,521. 30 cts.

Dynamo Connections — Circuits and Methods of Operating. Frank R. Jones. The first of a series of papers aiming to show some of the different modes of connecting dynamos to their circuits, the method of control and the operations of starting and stopping the machines when so connected. Tradesman—April 1, 1897. Serial. 1st part. No. 12,022. 15 cts.

Equalizing Connections for Compound-Wound Dynamos Coupled in Multiple. E. R. Keller. Shows the action of compound machines together with the equalizer connection and the function which it has to perform, giving methods of attaining the end desired. 2,700 w. Jour Fr Inst—March, 1897. No. 11,451. 45 cts.

ELECTRICITY.

The Handling of Electric Circuits, Arcs, &c. A. J. Wurts. Abstract of a lecture delivered before Sibley College. Deals with the handling of alternate and direct currents, describing apparatus, especially the Wurts switches. Ill. 3,500 w. Lib Jour of Engng—March, 1897. No. 11,681. 30 cts.

FAULTS.

See same title under "Lighting."

GENERATION of Electricity.

The Present Status of the Direct Generation of Electricity from Fuel. (Ueber die bisherigen Bestrebungen, Elektricität unmittelbar aus Brennstoffen zu erzeugen.) A historical review of the subject from the time of Mayer to the present day. Paper read before the Electrotechnic Society by Dr. Weber. 2,500 w. Elektrotechnische Zeitschr—Feb. 25, 1897. No. 11,763. 30 cts.

INDUCTION Coils.

An Improved Automatic Interrupter for Induction Coils. H. Lyman Sayen and Elmer G. Willyoung. Describes a new form of automatic interrupter, possessing many advantages over other forms. 1,000 w. Jour Fr Inst—March, 1897. No. 11,453. 45 cts.

INTER-CONNECTION.

Destruction of the Philadelphia Traction Company's Mount Vernon Street Station. Illustrated description, with diagram giving an idea of situation. 1,200 w. Elec Wld—March 13, 1897. No. 11,589. 15 cts.

ISOLATED Plant.

Electric Plant of the St. Paul Building, New York City. General description of the building, with illustrated detailed description of the electrical plant. 2,800 w. Elec Wld—March 27, 1897. No. 11,926. 15 cts.

LOSSES.

The Separation of the Losses of Three-Phase Motors and a Comparison of the Losses on Balanced and Unbalanced Circuits. Ernest B. True. Gives method of testing and the results. 2,000 w. Wis Eng—Jan., 1897. No. 11,854. 30 cts.

MINING.

See "Electricity" and "Hoisting," under Mining and Metallurgy, Mining and Coal and Coke.

MOTORS.

Electric Motors at the Baldwin Locomotive Works. Describes a change in machine shop practice. In place of the long line shafting to which the machines were belted, independent electric motors are used. Information in regard to the present status of the work of changing the shop methods. 2,200 w. RR Gaz—April 2, 1897. No. 12,002. 15 cts.

The Theory of Constant Speed Direct Current Motors. W. G. Rhodes. Investigates the compounding of motors so as to maintain a constant speed under all loads, up to a certain limit. 800 w. Elec Rev, Lond—Feb. 26, 1897. No. 11,522. 30 cts.

POLYPHASE.

Polyphase Electric Currents. Sketches briefly the chief features of the system. 1,400 w. Eng, Lond—March 19, 1897. No. 11,914. 30 cts.

POWER Station.

The Electric Plant at Rathausen, near Lucerne. (Das Elektricitätswerk Rathausen bei Luzern.) An extensive illustrated description of the new hydraulic electric plant near Lucerne—900 H. P. now in use, and at present being increased to 1,500 H. P. 7,500 w. Elektrotechnische Zeitschr—March 4, 1897. No. 11,764. 30 cts.

Design and Construction of Electric Power Plants. Broic J. Arnold. Part first discusses the possible sources of energy. 5,500 w. W Elec—April 3, 1897. No. 12,023. 15 cts.

PUMPING.

The Pumpinf Plant for Condensing Water at the Berlin Sxhibition, 1896. (Kondenswasser-Pumpenanlage auf der Berliner Gewerbeausstellung, 1896.) An account of the performance of two electrically driven centrifugal pumps, with table of data and efficiency. 1,200 w. Zeitschr d Ver deutscher Ing—Feb. 6, 1897. No. 11,704. 30 cts.

RESISTANCE.

A Simple Way of Testing the Resistance of a Field Coil When Instruments Are Not Available. Frank B. Porter. A simple device for testing the electrical resistance of a field. 600 w. Elec Wld—March 13, 1897. No. 11,587. 15 cts.

RHEOSTATS.

On the Construction and Calculation of Rheostats. P. M. Heldt. Considers only rheostats in which the resistance material is metallic wire. Illustrated description of dynamo field rheostats, motor-starting rheostats and motor-regulating rheostats. 2,500 w. Am Elect'n—March, 1897. No. 11,779. 15 cts.

ROCK Drilling.

Electric Rock Drilling by the Société de Charbonnages des Bouches-du-Rhone. Albion T. Snell. Particulars taken from a description by M. M. H. Dubs in the Bulletin de la Société Scientifique de Marseille of the Galerie de la Mer. Ill. 2,200 w. Elect'n—Feb. 26, 1897. No. 11,517. 30 cts.

STATION.

Light and Power Station at the Altofen Shipyards. (Elektrische Kraft und Lichtzentrale auf der Altofner Schiffswerft.) An illustrated account of the plant of the Danube Steam Navigation Company. Over 400 H. P. is distributed over the yards among small motors, besides 400 H. P. in lighting. 3,500 w. Zeitschr d Ver deutscher Ing—Feb. 27, 1897. No. 11,712. 30 cts.

See also "Boston" under Street and Electric Railways, Power; "Electricity" under Mining and Metallurgy, Mining, and "Station" under Street and Electric Railways.

STEAM ENGINE.

The Selection of a Power Plant Steam Engine. Abstract of a lecture delivered by Prof. Hutton at the rooms of the Amer. Inst. The questions discussed were high and low-speed engines, automatic cut-off engines as contrasted with throttling engines, and the arguments in favor of condensing engines. 1,500 w. Elec Wld—March 13, 1897. No. 11,586. 15 cts.

STORAGE BATTERY.

Storage Battery Engineering Practice. Joseph Appleton. Part first consists of introductory remarks and an explanation of the construction and operation of storage batteries. 1,600 w. Elec Eng—March 17, 1897. No. 11,620. 15 cts.

The Bowling Green Storage Battery Station of the New York Edison Co. A short account of the objects for which the battery has been installed and the work it accomplishes, with illustrated detailed description. 1,800 w. Elec Eng—March 10, 1897. No. 11,496. 15 cts.

The influence of Manganese in Accumulators. (Ueber den Einfluss von Manganverbindungen auf Bleiakkumulatoren.) An investigation of the action of the superoxide of manganese in storage batteries. Its presence is declared to be unfavorable, causing the battery to run down more rapidly when at rest. 1,500 w. Zeitschr f Elektrochemie—Feb. 20, 1897. No. 11,769. 30 cts.

TRACTION.

Electrically Driven Vehicles. A topical discussion opened by Mr. Andrew L. Riker. 1,200 w. Trans Am Inst of Elec Engs—Jan., 1897. No. 11,583. 45 cts.

TRANSFORMERS.

Rotary Transformers. J. E. Woodbridge. Description of a device without moving wire, which will perform the duties of both "static" and "rotary" transformers. 900 w. Elec Wld—March 27, 1897. No. 11,927. 15 cts.

Transformer Regulation. Joseph Bijur. An investigation of the causes which produce a drop of potential. 3,200 w. Elec Wld—March 27, 1897. No. 11,928. 15 cts.

TRANSMISSION.

Long Distance Electrical Transmission in California. Illustrated detailed description of the electrical transmission water power plant of Fresno. 4,000 w. Eng, Lond—March 5, 1897. No. 11,592. 30 cts.

Power Transmission on the Continuous Current Series System. J. S. Hecht. The principal characteristics of the series system, with description. Ill. 4,200 w. 25 and March 4, 1897. No. 11,762. 90 cts.

The Regla-Pachuca Power Transmission. George J. Henry. It is the purpose of the article to give a complete description of a high head water power and electric transmission plant in Mexico, and to point out what improvement may be effected in the development of mining and other industries in localities difficult of access. Ill. 2,700 w. Elec Wld—March 13, 1897. Serial. 1st part. No. 11,588. 15 cts.

Three-Phase Transmission. F. C. Armstrong. Illustrated description of three-phase transmission plant in the Montreal Cotton Company's mills, Valleyfield, Que. 800 w. Can Eng—March, 1897. No. 11,569. 15 cts.

TELEGRAPHY AND TELEPHONY.

AUTOMATIC Telephone.

Telephone System Without Calling De-

vice for Subscribers. (Fernsprechanlage-ohne Rufstromquellen bei den Theienehmerstellen.) Description of an automatic system by means of which the unhooking and hooking up of the receiver gives the call or rings off. Three articles. 5,000 w. Elektrotechnische Zeitschrift—Feb. 18 and 25 and March 4, 1897. No. 11,762. 90 cts.

BERLINER.

The Berliner Patent. Morgan Brooks. A suggestion regarding the legal status of this telephone patent, not previously brought out. 1,100 w. Elec—March 10, 1897. No. 11,530. 15 cts.

CABLE.

A Novel Method of Lifting a Buoyed Cable End. F. Alex Taylor. Brief description of the usual method as given by H. D. Wilkinson, with description also of a novel plan suggested and applied by a French telegraph engineer. 500 w. Elect'n—Feb. 26, 1897. No. 11,519. 30 cts.

Repairing Submarine Cable. H. Benest. On some repairs to the South American Company's cable off Cape Verdi in 1893 and 1895. A brief résumé of the establishment of the submarine telegraph between the coasts of Africa and Brazil, with some novel features affecting the cables. 3,300 w. Engng—March 12, 1897. Serial. 1st part. No. 11,831. 30 cts.

The "Rapid" Cable. Arthur Dearlove. Gives details of some observations made on two sections of a laid cable to determine the value of leak circuits. The results are not favorable. 900 w. Elect'n—Feb. 26, 1897. No. 11,518. 30 cts.

Telephone Cables. Dr. V. Wietlisbach. Talking through cables is considered, with the difficulties; how to overcome them by proper construction. 3,500 w. Elec Engng—April 1, 1897. No. 11,973. 25 cts.

The Air-Drying Process for Telephone Cables. Dr. V. Wictlisbach. The principles of the process, method, apparatus, &c. 1,700 w. Elec Engng—April 1, 1897. No. 11,974. 25 cts.

CABLE Testing.

Cable Testing. George D. Hale. Considers the questions: (1) How to manufacture such as will be suitable? (2) How to test the same during and immediately following the process of manufacture? (3) How to prevent their deterioration when laid? (4) How to locate the trouble in them when it arises? 1,800 w. W Elec—April 3, 1897. No. 12,024. 15 cts.

EXCHANGES.

Benefits Derived from Opposition Telephone Exchanges. C. E. Cory. Presentation of the benefits that telephone subscribers in Fort Scott have derived from competition; with editorial comment. 2,400 w. Elec Engng—April 1, 1897. No. 11,975. 25 cts.

The New Dey Street Telephone Building, New York City. Herbert Laws Webb. Illustrated detailed description of what is practically an enlargement of the present building. 5,500 w. Elec Eng—March 17, 1897. No. 11,620. 15 cts.

FIRE-ALARM.

Some Requisities of a Perfect Fire-Alarm Box. James W. Johnson. Read before the Illinois Firemen's Assn. Points out a few of the essential features that should be embodied in all boxes to render them reliable and efficient under the many and varying conditions. 1,200 w. W Elec—March 20, 1897. No. 11,798. 15 cts.

RESONANCE.

Some Practical Aspects of Electrical Resonance. Kempster B. Miller. Read before the Chicago Elec. Assn. Briefly outlines the underlying principles of resonance, and its relation to telegraphy and telephony. 3,700 w. W Elec—March 13, 1897. No. 11,579. 15 cts.

STORAGE Battery.

The Storage Battery in Telegraph Work. Maurice Barnett. Discusses their lower first cost, their lower maintenance cost, the smaller floor space required by them and their more satisfactory performance in service. Ill. 2,200 w. Am Elect'n—March, 1897. No. 11,783. 15 cts.

TELEPHONES.

How to Make a Telephone. E. E. Clement. Directions with illustrations. 2,000 w. Am Elect'n—March, 1897. No. 11,784. 15 cts.

TELEPHONY.

Long Distance Work. Dr. V. Wietlisbach. A careful discussion of all phases of long distance work and the methods and devices used. Ill. 25,900 w. Elec Engng—April 1, 1897. No. 11,972. 25 cts.

MISCELLANY.

ALUMINUM.

Recent Determinations of the Electrical Conductivity of Alumnium. Joseph W. Richards and John A. Thomson. Gives the causes of the various values determined for the electrical conductivity of this metal, with experiments and conclusions. 900 w. Jour Fr Inst—March, 1897. No. 11,450. 45 cts.

BATTERIES.

Two New Galvanic Elements. (Ueber zwei neue Galvanische Elemente.) The first is composed of two carbons, one in porous cell in clorine water, the other without in hyposulphite of soda; electromotive force 0.47 volt, very constant. The second is composed of an iron anode and carbon cathode in a concentrated solution of cloride of iron. Very constant; electromotive force 0.9 volt. 1,500w. Zeitschr d Elektro Chemie. Feb. 5, 1897. No. 11,767. 30 cts.

BURGLAR-PROOF.

The Modern Burglar. Carl E. Kammeyer. Illustrated description of work on safes by burglars with electricity, with description of protective device. 900 w.

Elec Rev. March 17, 1897. No. 11,619. 15 cts.

CELL.

The Lead Cell. B. E. Moore. A theoretical and experimental study, with results. 6,000 w. Phys Rev. March-April, 1897. No. 11,506. 45 cts.

CHARGES.

Methods of Charging for Electricity Supply. R. P. Wilson. Read before the Northern Soc. of Elec. Engs., Manchester, Eng. Names the systems in use, states the objects of any system, and considers the merits of the systems named. Ill. 3,400 w. Elec. March 24, 1897. No. 11,869. 15 cts.

CHINA.

Electricity and Electrical Engineering in China and Japan. R. Van Bergen. The writer gives but little encouragement to American enterprise in Japan, but considers China more hopeful, making suggestions as to the best way to secure attention. 1,000 w. Elec Eng. March 10, 1897. No. 11,497. 15 cts.

CURRENT.

The Insulating Medium Surrounding a Conductor the Real Path of Its Current. E. J. Houston and A. E. Kennelly. A brief description of the manner in which electric current is believed to be transmitted. Abstract of a paper read before the Am. Phil. Soc. 2,500 w. Elec Wld. March 27, 1897. No. 11,929. 15 cts.

ELECTRIC ENERGY.

Work in the Electric Current. (Ueber die Stromarbeit.) A mathematical discussion of the mechanical laws of energy applied to the flow of electricity. 3,500 w. Electrochemishe Zeitschr. Feb., 1897. No. 11,770. 45 cts.

ELECTRICITY.

Epoch-Making Events in Electricity. G. H. Stockbridge. Describing Volta's experiments and the succession of electricity of motion to that of tension. Ill. 4,200 w. First paper. Eng Mag. April, 1897. No. 12,049. 30 cts.

GERMINATION.

Amherst Experiments on the Electro Germination of Plants. Extended abstract from a bulletin issued by the Hatch Experiment Station of the Massachusetts Agricultural College describing a series of experiments carried out by Mr. Asa S. Kinney. Ill. 2,400 w. Elec Eng. March 17, 1897. No. 11,622. 15 cts.

MAGNETISM and Light.

The Latest Discovery in Physics. Oliver Lodge. Reviews the work of Faraday and others, giving special attention to the discovery of Dr. P. Zeeman. 2,500 w. Elect'n. Feb. 26, 1897. No. 11,516. 30 cts.

MAGNETO-ELECTRICITY.

On the Mechanical Conceptions of Electricity and Magnetism. W. S. Franklin. Read before the Buffalo meeting of the Am. Assn. Develops the conceptions of the dependence of electro-motive force upon changing magnetic flux, of the dependence of magneto-motive force upon changing electric flux, of the production of electro-motive force in a moving wire, of the energy stream, of electro-magnetic waves, and of the Hertz vibrator. 3,000 w. Phys Rev—March-April, 1897. No. 11,508. 45 cts.

RADIOGRAPHY.

Recent Progress in Instantaneous Radiography. (Les progrès Récents de la Radiographie Instantanée.) An account of the methods and apparatus by means of which M. Colardeau has succeeded in obtaining radiographs in the 250th part of a second. 1,500 w. Le Génie Moderne—Feb. 15, 1897. No. 11,748. 30 cts.

RESONANCE.

Electric Resonance and Consonance. (Ueber Elektrische Resonanz und Konsonanz). Two papers by Herr C. P. Feldmann, giving an analytical investigation of the theory with graphical applications. 7,500 w. Elektrotechnische Zeitschr—Feb. 18 and 25, 1897. No. 11,772. 30 cts.

ROENTGEN RAY.

On the Manipulation of Röntgen-Ray Apparatus. George T. Hanchett. The experimental experience of the writer with a number of tubes under varying conditions. 1,200 w. Elec Wld—March 20, 1897. No. 11,811. 15 cts.

SAFES.

Burglarizing Safes by Electric Heat. Is It Feasible? Discusses recent articles that have appeared setting forth this new danger threatening safes, and quotes the authority of expert electricians in proof that there is no need of great anxiety on the subject. 3,400 w. Elec Eng—March 31, 1897. No. 11,956. 15 cts.

STEEL.

The Influence of Heat Treatment Upon the Magnetic Properties of Hardened Steel. Dr. K E. Guthe. Abstract of a paper presented at meeting of Am. Inst. of Elec. Engs. A contribution to knowledge of the dependence of magnetic properties upon the percentage of carbon present and the character of the heating. A report of careful investigations. 2,500 w. Elec Wld—March 27, 1897. No. 11,925. 15 cts.

SUBWAYS.

The Electrical Subways in Utica, N. Y. Illustrated description of the city subways and account of their cost. 900 w. Eng Rec—March 6, 1897. No. 11,457. 15 cts.

X RAYS.

X-Rays, Apparatus and Methods. Elmer G. Willyoung and H. Lyman Sayen. Discusses apparatus and methods for practical work, with especial reference to the needs of the physician and surgeon. Ill. 7,000 w. Jour Fr Inst—March, 1897. No. 11,452. 45 cts.

See also Radiograph and X Ray, above.

MARINE ENGINEERING.

BATTLESHIPS.
Thames-Built Battleships. Illustrations and general description of the Fuji, built for the Japanese Navy by Thames Iron Works. 4,400 w. Engng—March 12, 1897. No. 11,829. 30 cts.

COAST Defense.
See same title under Electrical Engineering—Lighting.

COMPRESSED Air.
Compressed Air System on the United States Monitor Terror. Engravings and description of duties performed by compressed air. 2,000 w. Sci Am—March 20, 1897. No. 11,667. 15 cts.

FURNACES.
Collapse of a Pair of Corrugated Furnaces. From the "Locomotive." Illustrated description of an accident which took place in one of the four compound marine boilers of the whaleback steamer City of Everett. 800 w. Ir Age—March 11, 1897. No. 11,532. 15 cts.

LIQUID FUEL.
Liquid Fuel Under Marine Boilers. (Heizung der Schiffskessel mit flüssigem Brennstoff.) A general statement of the advantage of liquid fuel, and a resumé of the results obtained in actual practice. 2,000 w. Glaser's Annalen—March 1, 1897. No. 11,721. 30 cts.

ELECTRIC Light.
Electric Light Plants for the British Navy. Illustrated description of a pattern of combined engine and dynamo set designed for the ships "Majestic," "Magnificent," "Terrible," "Powerful," "Diadem" and "Andromeda" class. 300 w. Elec'n—March 5, 1897. No. 11,652. 30 cts.

NEW YORK.
New York Harbor. The necessity for a 35-foot channel from the Narrows to the sea. Report of Col. G. L. Gillespie. 800 w. Sea—March 11, 1897. No. 11,576. 15 cts.

NIOBE.
The Launching of H. M. S. "Niobe." Illustrated description of the launching and of the cruiser. 3,000 w. Engng—March 5, 1897. No. 11,597. 30 cts.

PROPELLERS.
Screw Propellers for Canal-Boats. Henry Barcroft. Consideration of the principles involved in the action of partially immersed screw propellers for canal-boats, with the experience resulting from experiments and observations on the influence of section of waterway upon the progress of canal-boats. Ill. 3,300 w. Engng—Feb. 26, 1897. No. 11,505. 30 cts.

PROPULSION.
Mechanical Propulsion on Canals. Leslie S. Robinson. Part first reviews early investigations, with study of resistance on rivers. 3,000 w. Ind & Ir—March 5, 1897. Serial. 1st part. No. 11,604. 30 cts.

PURITAN.
U. S. Monitor "Puritan." Illustrated description of the largest craft of her class. 1,100 w. Eng, Lond—March 19, 1897. No. 11,915. 30 cts.

RESISTANCE.
Resistance of Ships and Other Floating Bodies at Deep and Shallow Drafts of Water. Joseph R. Oldham. Convictions and opinions held by eminent scientists and engineers on the resistance offered by water to ships floating therein are examined, with general remarks. 5,000 w. Jour Assn of Engng Soc—Feb., 1897. No. 11,892. 30 cts.

RACING.
The Prevention of Racing in Marine Engines. L. Harlan. Describes invention of J. S. Yabsley, of Yokohama, to effect by electrical means the closing and opening of a throttle valve, which regulates the supply of steam to the engines. Ill. 1,200 w. Elec Rev, Lond—Feb. 26, 1897. No. 11,520. 30 cts.

SHIPBUILDING.
About Merrimac Ship Building. Horace C. Hovey. Facts of interest concerning the history and progress of ship building. Ill. 1,400 w. Sci Am—March 13, 1897. No. 11,534. 15 cts.

SHIPPING.
American Merchant Shipping. Editorial discussion of ideas advanced by Captain Alexander McDougall. 1,600 w. Eng, Lond—March 19, 1897. No. 11,918. 30 cts.

STEAMER.
The New German Mail Steamer König. Illustrated description of a new steamer in service between Hamburg and the German colonies in East Africa. 500 w. Sci Am Sup—March 13, 1897. No. 11,535. 15 cts.

The Plant Line Steamship "La Grande Duchesse." Illustrated description of new steamship running between New York and Savannah. 700 w. Eng News—March 25, 1897. No. 11,879. 15 cts.

The Niger stern-wheel steamers "Empire" and "Liberty." Two-page plate with description. 1,400 w. Engng—March 12, 1897. No. 11,828. 30 cts.

WARSHIPS.
Our Warships. William Allan. A criticism of modern ships showing that fitted with boilers, as they have been and are being at present, are not reliable, are far from safe, and not the best. 3,000 w. Contemporary Rev—March, 1897. No. 11,643. 45 cts.

WATER-TIGHT Doors.
O'Brien's Water-tight Doors for Ships.

Illustrated description. 800 w. Steamship—March, 1897. No. 11,572. 30 cts.

WATER-TUBE Boilers.

Salt-Water Feed for Express Boilers. Details of experiments made by Messrs. Yarrow & Co., in which salt water was used as feed, showing that in case of a complete breakdown of the condenser a vessel fitted with these small tube boilers would be safe for a considerable distance of steaming. 1,700 w. Engng—March 19, 1897. No. 11,906. 30 cts.

Salt-Water in Water-Tube Boilers. Editorial comment on the experiments made by Messrs. Yarrow & Co. 1,400 w. Eng, Lond—March 19, 1897. No. 11,917. 30 cts.

Water-Tube Boilers for H. M. S. "Pelorus." Drawings of boilers and engines, with description. The small-tube boiler was adopted for the first time in cruisers, and results of trials are given. 1,400 w. Engng—March 19, 1897. No. 11,908. 30 cts.

YACHT.

The Twin-Screw Yacht Varuna. Illustrated description of yacht built for Mr. Eugene Higgins, of New York, by Messrs. A. & G. Inglis, of Glasgow. 1,500 w. Eng, Lond—Feb. 26, 1897. No. 11,514. 30

MECHANICAL ENGINEERING.

BOILERS, FURNACES AND FIRING.

BOILER.

The Steam Boiler. Stephen Christie discusses the effect of location and cites some of the requirements looked for in the selection of boilers. 2,000 w. Safety V—March, 1897. No. 11,623. 15 cts.

Progress in Heating Boiler Construction. Hugh J. Barron. A study of the boiler problem with sketches of work done by the writer. 700 w. Heat and Ven—March 15, 1897. Serial. 1st part. No. 11,826. 15 cts.

See also "Boilers" under Mining and Metallurgy Mining.

CHIMNEYS.

Self-Supporting Metal Chimneys. C. G. Robbins. Discusses their design and construction. Ill. 5,800 w. Power—April, 1897. No. 12,016. 15 cts.

COAL Handling.

Coal-Handling for Large Boiler Plants. Illustrated description of the manner in which the problem has been worked out at the Ridgewood Pumping Station of the Brooklyn Water-Works and at the power stations of two of the Brooklyn street railway companies. 1,300 w. Sci Am Sup—March 20, 1897. No. 11,669. 15 cts.

EFFICIENCY.

Limitations of the Efficiency of Steam Boilers. Editorial calling attention to claims made in boiler tests that cannot be correct. 1,600 w. Eng News—March 18, 1897. No. 11,793. 15 cts.

EXPLOSION.

Boilers at Acushnet Mill, New Bedford, Explode. An account of an explosion which killed two employees and destroyed much personal property. 1,000 w. Bos Jour of Com—March 16, 1897. No. 11,475. 15 cts.

The New Bedford Explosion. Calls attention to interesting features in connection with a recent explosion. 1,600 w. Bos Jour of Com—March 20, 1897. No. 11,799. 15 cts.

FEED-PUMPS.

Boiler Feed Pumps. C. A. Collett. The abuses of the steam pump, with explanation of its construction and functions. 1,600 w. Am Electn—March, 1897. No. 11,782. 15 cts.

FEED-WATERS.

The Cure for Corrosion and Scale from Boiler Waters. Albert A. Cary. Detailing the impurities that cause the formation of scale, and the methods of treating them. 7,400 w. Second paper. Eng Mag—April, 1897. No. 12,052. 30 cts.

GAS Firing.

A Gas-Burning Water Heater or Steam Boiler. Illustrated description of invention of John S. Coe. 800 w. Am Mach—March 18, 1897. No. 11,662. 15 cts.

HEAT Exchanges

The Exchanges of Heat Between the Steam and the Cylinder Walls. (Der Uebergang der Wärme Zwischen dem Dampf und den Wandungen der Dampfcylinder.) Prof. A. Fiegner. A valuable mathematical and graphical treatment of this important subject. Three articles. 10,000 w. Schweizerische Bauzeitung—Feb. 27, March 6 and 13, 1897. No. 11,737. 45 cts.

LICENSE.

The Certification of Boiler and Engine Attendants. Editorial discussion of the bill before the House of Commons to secure the granting of certificates to persons in charge of engines and boilers. 2,400 w. Engng—March 5, 1897. No. 11,599. 30 cts.

SAFETY-VALVE.

Safety-Valve Practice. F. F. Hemenway. Discusses the requirements of safety-valves and the means of deciding on the area. 1,300 w. Am Mach—March 11, 1897. No. 11,537. 15 cts.

STEAM.

Some Notes on Steam-Raising. Frank Leslie Watson. Read before the Association of Yorkshire students of the Institution of Civil Engineering. Part first introduces the advantages of forced draught. Ill. 2,500 w. Elec Rev Lond—Feb. 26, 1897. Serial. 1st part. No. 11,523. 30 cts.

STEAM Loop.
The Steam Loop. Its use, the principles upon which it acts, &c. 1,300 w. San Plumb—March 15, 1897. No. 11,629. 15 cts.

WATER-TUBE Boilers.
Water Tube vs. Shell Boilers. W. Barnet Le Van. An account of comparative tests made between water-tube boilers and shell or horizontal flue boilers at the establishment of the Brush Electric Light Co., Philadelphia, in October, 1882. 3,500 w. Mach—March, 1897. No. 11,-485. 15 cts.

See also same title under Marine Engineering.

COMPRESSED AIR.

AIR Compression.
Theoretical Modes of Air Compression. Lemuel R. Hopton. A short outline of the various modes of compression, with a comparison of their efficiency and advantage. 1,500 w. Yale Sci M—March, 1897. No. 11,684. 30 cts.

AIR-COMPRESSOR.
Hydraulic Air-Compressor Plant at Magog. Illustrated description of a 150 h. p. compression plant erected for the Dominion Cotton Mill Co. as a test system, by the Taylor Hydraulic Air-Compressing Co. 2,400 w. Can Eng—March, 1897. No. 11,567. 15 cts.

A Description of the 150-Horse Power Hydraulic Air Compressor Erected for the Dominion Cotton Mills Company, at Magog, Que. C. H. Taylor. Illustrated description with results of tests. 2,800 w. Can Min Rev—March, 1897. No. 12,038. 30 cts.

CAISSON.
See Civil Engineering—Canals, Rivers and Harbors.

LOCOMOTIVE.
Test of a Compressed Air Locomotive for the Anaconda Copper Mining Company. Description, illustration and data of tests, as obtained from H. K. Porter & Co., of Pittsburg. 1,200 w. Ry Rev—March 27, 1897. No. 11,952. 15 cts.

NAVAL Use.
See "Compressed Air" under Marine Engineering.

PAINTING.
See Railroad Affairs—Equipment.

SNOW PLOW.
See Street and Electric Railways.

TRACTION.
See "Air Cars" under Street and Electric Railways.

ENGINES AND MOTORS.

CONDENSERS.
Central Condensing (Balcke System.) C. Habermann. Describes a system used at several collieries and iron works in Germany, resulting in saving of coal. Ill. 1,500 w. Col Guard—March 12, 1897. No. 11,834. 30 cts.

DYNAMO Construction.
The Relative Size, Weight and Price of Dynamos, Electric Machines. Ernest Wilson. Read at meeting of Inst. of Elec. Engs., England. Investigates the way in which weight and price of dynamo-electric machines vary with the variation of the mass factor. Tables, curves and discussion. 3,000 w. Elec Eng, Lond—March 5, 1897. No. 11,593. 30 cts.

GAS Engines.
An Improvement in Gas Engines. (Eine Neuerung an Gaskraftmaschinen.) A paper before the Berlin branch of the society by Dr. Petreano, showing the odvantages of mixing and preheating the air and gas. 3,000 w. Zeitschr d Ver deutscher Ing—Feb. 6, 1897. No.

Recent Developments in Gas Engines. Dugald Clerk. Read before the Inst. of Civ. Engs. A review of advances made in the construction and efficiency of gas engines. Part first considers mainly the engines working in accordance with the Otto Cycle, with results of tests. Ill. 6,500 w. Eng News—April 1, 1897. Serial. 1st part. No. 12,013. 15 cts.

Gas and Gasoline Motors. From Revue Industrielle. Illustrated description of the Lair-Delay Gas Motor, exhibited at the Rouen Exposition. 1,200 w. Sci Am Sup—April 3, 1897. No. 11,981. 15 cts.

GASOLINE Motor.
A Small High Speed Gasoline Motor. W. O. Amsler. Illustrated description of a special design by Mr. Gottlieb Daimler, of Cronstadt, Germany. 1,700 w. Sib Jour of Engng—March, 1897. No. 11,683. 30 cts.

OIL Engines.
The Oil Machine. George Richmond. Historical review of oil engines, with methods used, and principles involved efficiency, &c. 4,500 w. Sch of Mines Quar—Jan., 1897. No. 11,990. 45 cts.

ROTARY Engine.
The Rotary Steam Engine. R. H. Thurston. Stating that the prototypes of the most successful of recent forms of rotary engines date back to Hero, of Alexandria, and showing that this engine has usually failed to satisfy in all the essential characteristics of a good steam engine. Ill. 1,600 w. Sci Am—April 3, 1897. No. 11,979. 15 cts.

Rotary Pumps and Engines: Their Origin and Later Development. Historical review of the inventions of this class of engines, with illustrations. 1,800 w. Sci Am Sup—April 3, 1897. Serial. 1st part. No. 11,980. 15 cts.

STEAM Engines.
The steam engines at the Geneva Exhibition in 1896. (Die Dampfmaschinen auf der Schw. Landes-Ausstellung in Genf, 1896.) The first of a series of articles. This contains drawings and description of vertical compound engine by Sulzer Bros. of Winterlhur. 3,000 w.

Schweizerische Bauzeitung—March 13, 1897. No. 11,741. 30 cts.

VALVE Motions.

A Rational Method of Studying Valve Motions. Henry Hess. Method devised by the writer to trace and show up the performance of a certain complicated valve gear. Ill. 1,700 w. Mch—April, 1897. No. 12,029. 15 cts.

VALVE Setting.

Valve Setting on Steam Pumps. Details of valve gear as shown on the Deane, of Holyoke, pumps are given and discussed; also the Deane duplex pump, and a compound duplex pump. Ill. 1,800 w. Power—April, 1897. No. 12,015. 15 cts.

See also Electrical Engineering Power.

POWER AND TRANSMISSION.

BELTING.

Rules for Belting. Calls attention to rules that should be observed to obtain the greatest economy and most satisfactory results. 1,800 w. Engng Mech—March, 1897. Serial. 1st part. No. 11,867. 30 cts.

ROPEWAYS.

Various Types of Ropeways. W. Carrington. Read at meeting of the Federated Institution of Mining Engs. Describes types and makes remarks as to their proper selection. 2,500 w. Col Guard—March 19, 1897. No. 11,913. 30 cts.

SHOP AND FOUNDRY.

BRONZE.

Phosphor Bronze. Max H. Wickhorst. Read before Western Foundrymen's Assn. Gives the process of manufacture used by the C., B. & Q. R. R. brass foundry at Aurora, Ill. 2,000 w. Ir Age—March 25, 1897. No. 11,861. 15 cts.

CAMS.

The Drafting of Cams. Louis Rouillion. The use of cams is explained, and the process of laying them out, with diagrams. 1,400 w. Mach—March, 1897. Serial. 1st part. No. 11,483. 15 cts.

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The Capitalization of Mining Companies. Editorial disucssion of this method of doing business, and the importance of the adjustment of capital to a moderate estimate of the value of a mining property. 1,400 w. Min Jour—March 6, 1897. No. 11,596. 30 cts.

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Boring a Mine Heading by Electricity. From Le Génie Civile. Describes the system recently adopted by the Société de Charbonnages des Bouches-du-Rhône for driving a gallery. The electrical energy employed as motive power is generated by the pressure of the pit water. Ill. 2,300 w. Col Guard—Feb. 26, 1897. No. 11,513. 30 cts.

Central Electric Station of the Davis Coal and Coke Company. Timothy W. Sprague. Illustrated detailed description with information regarding the operation of the plant. 2,500 w. Elec Rev—March 10, 1897. No. 11,494. 15 cts.

Electricity in Mining. Discussion of the papers on "Electric Mining in the Rocky Mountain Regioin," by Irving Hale, and "Addition to the Power Plant of the Standard Consolidated Mining Company," by Robert G. Brown. 8,000 w. Trans Am Inst of Min Engs—March, 1897. No. 11,957. 45 cts.

EASEMENTS.

Mining Easements. An explanation of the law relating to easements in England. 2,200 w. Col Guard—March 5, 1897. No. 11,632. 30 cts.

HOISTING.

The Electric Motor for Hoisting in Mines. Illustrated description of the electrical hoist at the Free Silver Mine, at Aspen, Col., with account of test. 1,000 w. Ir Age—April 1, 1897. No. 11,983. 15 cts.

Preliminary Hoisting Plant for Mines. Robert Peele. An account of the hoisting appliances appropriate to the temporary work generally preceding serious mining operations, and sometimes also employed in connection with the development of mines. Ill. 2,400 w. Sch of Mines Quar—Jan., 1897. No. 11,986. 45 cts.

LEVELLING.

Levelling in Mines. Bennett H. Brough. Abstract of a lecture given at Chesterfield, Eng. Describes the various forms of levelling instruments used in mines. 1,700 w. Col Guard—March 19, 1897. No. 11,911. 30 cts.

MACHINERY.

The Growing Efficiency of Modern Mining Machinery. Cyrus Robinson. Describing electrical coal-cutters, drills, mine pumps, and mine locomotives, and the conditions under which they may be used advantageously. Ill. 2,700 w. Eng Mag—April, 1897. No. 12,053. 30 cts.

MINE Management.

Mines and Management. Robert Archibald. Devoted mostly to mine management, especially of men. 6,500 w. Can Min Rev—March, 1897. No. 12,032. 30 cts.

MINING.

The Mechanics of Mining. D. W. Robb. Read before the Canadian Mining Assn. Deals with the successful operation of a mine. 1,400 w. Can Eng—March, 1897. No. 11,568. 15 cts.

ROCK Drilling.

See same title under Electrical Engineering—Power.

VENTILATION.

Contribution to the Study of Mine Ventilation. M. G. Hanarte, with explanations by J. W. P. Gives the Hanarte ar-

rangement of fan and its method of work. 2,500 w. Col Guard—March 12, 1897. Serial. 1st part. No. 11,833. 30 cts.

Notes on the Ventilation of Mines. T. A. Southern. A lecture delivered at University College, Nottingham. Part first discusses the pressure which produces ventilation; exhausting fans vs. forcing fans; upcast or downcast, which should be the larger, &c. 7,800 w. Col Guard—March 19,1897. Serial. 1st part. No. 11,909. 30 cts.

VICTORIA.

State Aid to Mining in Victoria. C. C. Longridge. The article approves the action of the State in mining matters, explains ways in which the government have undertaken to assist capitalists, and discusses matters of interest. 1,000 w. Min Jour—Feb. 27, 1897. No. 11,594. 30 cts.

WATER.

Appliances for Winding Water. W. Galloway. Explains an instance in the experience of the writer where the water of a mine was raised by winding it to the surface up a vertical shaft. 1,000 w. Ir and Coal Trds Rev—Feb. 26, 1897. Serial. 1st part. No. 11,560. 30 cts.

MISCELLANY.

ALLOYS.

Alloys. W. C. Roberts-Austen. Abstract of the first of a new series of Cantor lectures. Describes methods of investigation. 1,000 w. Min Jour—March 20, 1897. No. 11,933. 30 cts.

ASBESTOS.

Asbestos Mining and Dressing at Thetford. H. Nelles Thompson. Conducted by quarrying. The methods are explained. 1,600 w. Can Min Rev—March, 1897. No. 12,039. 30 cts.

BRITISH COLUMBIA.

Notes on Some Mining Districts in British Columbia. John E. Hardman. Records facts and observations obtained during a trip in the summer of 1896. Touches briefly the geology, ore, production, &c., of the different districts. 5,000 w. Can Min Rev—March, 1897. No. 12,033. 30 cts.

COLORADO.

The Development of Colorado's Mining Industry. T. A. Rickard. Historical account. 5,000 w. Trans Am Inst of Min Engs—March, 1897. No. 11,970. 45 cts.

The Undeveloped Economic Resources of Colorado. Arthur Lakes. From Denver "News." Gives general geological section of the formations, and locates what each contains; includes ryolite lava, clays and coal, plastic clays, oil-bearing zone, limestone, sandstones and fire clay, gypsum, lithographic stone, marbles, granite, slate and onyx. Ill. 4,000 w. Stone—March, 1897. No. 11,659. 30 cts.

GALICIA.

The Mines of Galicia. Report on mines of gold, tin, copper, antimony, iron, coal, plumbago, asbestos and slate. 2,000 w. Cons Repts—March, 1897. No. 11,874. 45 cts.

GEMS.

Australian Gems. An account of the diamond field at Bingara, New South Wales, with information regarding other gems found in Australia. 1,800 w. Aust Min Stand—Feb. 11, 1897. No. 11,687. 30 cts.

MANGANESE Deposits.

The Manganese Deposits of the Department of Panamá, Republic of Colombia. Eduardo J. Chibas. Gives location, history, character of the ore, geological features, &c., with suggestions as to the origin. Ill. 4,300 w. Trans Am Inst of Min Engs—March, 1897. No. 11,966. 45 cts.

MINING Camp.

The Geology of a Typical Mining Camp in New Mexico. C. L. Herrick. Describes the Magdalena mountain range as illustrating many conditions of mineral accumulation and a variety of geological problems. 2,800 w. Am Geol—April, 1897. No. 11,985. 45 cts.

PICTOU Mines.

A Review of the Report of the Commission on Fires in Pictou Mines. H. S. Poole. Read before the Mining Soc. of Nova Scotia. An explanation and criticism of this report. 4,700 w. Can Min Rev—March, 1897. No. 12,034. 30 cts.

PLATINUM.

A Large Nugget of Platinum. Cyrus O. Baker. Interesting facts relative to the supply and consumption of this rare metal. Ill. 1,500 w. Elec Rev—March 24, 1897. No. 11,865. 15 cts.

SLATE.

Slate Production in the United States. James Hess. A review of the slate industry, the different localities, variaties, &c., with description of operation of slate quarries. 1,800 w. Yale Sci M—March, 1897. No. 11,685. 30 cts.

SOUTH AFRICA.

The Chartered Company in South Africa. John Mackenzie. Reviews the record of the company and criticises the policy and influence. 11,000 w. Contemporary Rev—March, 1897. No. 11,642. 45 cts.

TEMPERATURES.

Subterranean Temperatures at Wheeling, W. Va., and Pittsburg, Pa. W. Hallock. Observations taken from two remarkable wells of 4,500 feet and 5,386 feet in depth. Ill. 1,500 w. Sch of Mines Quar—Jan., 1897. No. 11,991. 45 cts.

TURQUOISE.

Turquoise Mining in Mexico. W. C. Fenderson. Refers to superstitions relating to this stone because of its change of color, and gives brief account of method of mining. 2,200 w. Min & Sci Pr—March 6, 1897. No. 11,539. 15 cts.

MUNICIPAL ENGINEERING.

GAS SUPPLY.

ACCIDENT.

The Accident to the Rope-Guarded Gasholder at Middlesbrough. Report relating to the recent accident to the rope-guided gasholder at the Corporation Gas Works. 2,000 w. Jour Gas Lgt—March 16, 1897. No. 11,944. 30 cts.

ACETYLENE.

Acetylene. A discussion of the properties, its dangerous qualities and advantages as an illuminant. 1,200 w. Fire and Water—March 6, 1897. No. 11,478. 15 cts.

A German Conference on Acetylene. A summary, compiled from the Journal für Gasbeleuchtung" of the conference proceedings of the German Society of Chem, Ind., giving the precautions considered necessary. 1,500 w. Jour Gas Lgt—March 23, 1897. No. 11,999. 30 cts.

Automatic Generators of Acetylene (Générateurs Automatiques d'Acetylene.) Illustrated description of improved Acetylene Generator; also Acetylene for Generating the Gas as needed for immediate use. 1,000 w. La Génie Moderne. Feb., 15, 1897. No. 11,745.

Report upon Acetylene Gas (Bericht über den corporativen Besuch des von der Acteylengas-Gesellschaft Demonstration). A report of the visit of a committee of the Society of Austrian Engineers to an exhibition of Acetylene Gas. With illustrations of Generators, &c. 2,500 w. Zeitsch. d. Oesterr. Ing. u. Arch. Ver.—Feb., 26, 1897. No. 11,734.

AMMONIA.

Does the Manufacture of Sulphate of Ammonia pay in Small Works? J. Wilkinson, read before the Manchester Dist. Inst. of Gas Engs. Discusses the subject, concluding that the intermittent still is the most efficient method to adopt at small gas works. Duscussion. 4,000 w. Jour Gas Lgt—March 2, 1897. No. 11,578. 30 cts.

ANALYSIS.

A Technical Analysis of Hydrocarbon, Vapor and Gasses in Literature and Laboratory. Dr. W. H. Birchmare. Part first, consists of an examination of methods and published work in this field, and will be followed by personal work of the writer. 2,500 w. Am Gas Lgt Jour—March 22, 1897. Serial, 1st part. No. 11,844. 15 cts.

BELFAST.

Cost of Illuminating Gas in Belfast. Consular report on the cost of the material and labor required for the manufacture of gas ready for consumption. The price to consumers is 60 cents per 1,000 cubic feet. 500w. Con Repts—April, 1897. No. 11,919. 45 cts.

CALORIMETRY.

Calorimetry. C. D. Jenkins. Brief account of investigations with short discussion. 1,200 w. Am Gas Lgt Jour—March 22, 1897. No. 11,842. 15 cts.

CARBIDE of Calcium.

Restrictions Placed on Carbide of Calcium in England. Notification issued by the English Home Office regarding the keeping of Carbide of Calcium. 700 w. Pro Age—April 1, 1897. No. 11,982. 15 cts.

COKE Ovens.

Some Remarks on Coke Ovens and Their Products. S. J. Fowler. Description of the Semet Solvay Oven, located at the works of the Solvay Process Co., in Syracuse, N. Y., with drawing. The illuminating coal gas plant and the retort Coke Oven plants are compared, and related matters examined. Discussion follows. 4,000 w. Am Gas Lgt Jour—March 8, 1897. No. 11,481. 15 cts.

FLAMES.

The Source of Light in Flames. Arthur Smithells. Report of a lecture at the Royal Inst. A study of the flames of various gases. 2,200 w. Gas Wld—March 20, 1897. No. 11,937. 30 cts.

FLOW.

The Flow of Gas or Steam Through Pipes. Arthur J. Martin. Table of the flow of gas or steam through pipes, with an examination of some of the formulae now in use. 2,500 w. Engng.—March 19, 1897. No. 11,903. 30 cts.

GAS.

Some Comparisons of Gas Making, from 1853 to December, 1896, and Some of the Writer's Experiences at the Small Gas Works at Fitchburg. The paper is almost entirely devoted to gas-making in Fitchburg, and is followed by short discussion. 2,000 w. Am Gas Lgt Jour—March 22, 1897. No. 11,843. 15 cts.

GAS Distribution.

Gas Distribution. William H. Snow. Read before the New England Assn. of Gas Engs. Refers to pipes, cocks, gates, naphthaline, &c., and is followed by discussion. 5,800 w. Am Gas Lgt Jour—March 8, 1897. No. 11,479. 15 cts.

GAS Industry.

Inaugural Address of Robert Porter. Reviews progress during the present reign, with comparison of the advantages of carbureted water- gas with coal-gas. 4,000 w. Jour Gas Lgt—March 2, 1897. No. 11,577. 30 cts.

LEAKS.

Reports of Gas Leaks. Their Management by a Large Company. W. R. Ad-

dicks. A statement of the system adopted in Boston, considering their management, when they occur, and the methods adopted to prevent their occurrence. Discussion follows. 7,500 w. Am Gas Lgt Jour—March 22, 1897. No. 11,841. 15 cts.

MEASUREMENT.

Measurement of Gas. C. W. Hinman. Read before the New England Assn. of Gas Engineers. Consisting the apparatus used for measuring the requisites of gas meters, diphragms, capacity, &c., with discussion. 4,800 w. Am Gas Lgt Jour—March 15, 1897. No. 11,591. 15 cts.

MINERAL Oils.

Determining the Gas-Making Value of Mineral Oils. Dr. F. Helfers. Abstract translation from the "Zeitschrift fuer Angewandte Chemie. Results of thests made by the use of Wernecke's Laboratory Gas-Making Apparatus, which gives correct results from the gasification of 1.4 oz. of oil. 1,300 w. Jour Gas Lgt—March 23, 1897. No. 12,000. 30 cts.

OIL.

The Application of Oil for the Production of Illuminating Gas. C. Hunt. Read before the Midland Assn of Gas Managers. Gives brief instorical review, extant processes, effect of temperature, the Peebles process, &c. 4,500 w. Gas Wld—Feb., 27, 1897. No. 11,529. 30 cts.

PURIFICATION.

The Use of Atmospheric Air with Lime for the Purification of Coal Gas. S. Carpenter. Remarks from the writer's experience. 800 w. Jour of Gas Lgt—March 9, 1897. No. 11,686. 30 cts.

TEMPERATURE.

The Effect of Temperature upon Gas. W. E. McKay. Read before the New England Assn. of Gas Engs. Gives table for carburetted water-gas saturated with aqueous vapor, no other vapors being present, showing the changes made by change of temperature, with discussion of the subject by the writer and members. 8,400 w. Am Gas Lgt Jour—March 8, 1897. No. 11,480. 15 cts.

WATER Gas.

Carburetted Water Gas. J. T. Wastcott. A paper read before the Civil and Mech. Engs. Ass., given in abstract. Reviews the processes now in successful use, describes the combined type. 1,800 w. Gas Wld—March 20, 1897. No. 11,938. 30 cts.

Inaugural Address of Mr. John Young, before the Midland Association of Gas Managers. The address is largely confined to experiences in Hanley. Carburetted water gas, naphthalene deposits, and other subjects of interest are discussed. 6,000 w. Gas Wld—Feb., 27, 1897. No. 11,528. 30 cts.

SEWERAGE.

ASSESSMENTS.

Sewer Assessments. F. Herbert Snow. Discusses the fundamental object of assessment, the frontage plan, area plan, frontage and area combined, entrance fee plan, valuation, rental, Brocton plans, &c. Followed by discussion and reports from various cities of Mass. 2,500 w. Jour Assn of Engng Soc—Jan., 1897. No. 11,785. 30 cts.

FILTRATION.

Denny and Duniface Sewage Filtration Works. Drawings and photograph of these sewage filtration works, with description. The whole of the sewage is treated by intermittent downward filtration. 700 w. Eng, Lond—March 12, 1897. No. 11,819. 30 cts.

The Operation of the Pawtucket, R. I., Sewage Filter Beds. Information of the successful operation of sand filters. 700 w. Eng Rec—March 6, 1897. No. 11,458. 15 cts.

INCINERATION.

The Incineration of the Sewage of Paris. (L' Incineration des Gadoues de Paris.) A discussion of the various processes for incinerating solid refuse, with especial reference to the introduction of such apparatus into Paris. Descriptions of the Oldham, Javel and Horsfall furnaces. 3,000 w. La Revue Technique—Feb. 25, 1897. No. 11,752. 30 cts.

PURIFICATION.

The Purification of Sewage and Water. W. J. Dibdin. It is proposed in this series of articles to place on record the results arrived at in the personal experience of the writer. The purification of the river Thames revealed facts which established principles that have been adopted generally. The subject will be fully dealt with and the practical application considered. 4,000 w. San Rec—March 5, 1897. Serial, 1st part. No. 11,627. 30 cts.

RIVER Pollution.

Report of the Passaic Valley Sewerage Commission. Gives recommendations of the Commission to remedy the pollution of this stream. Also editorial comment. 2,200 w. Eng News—March 11, 1897. No. 11,547. 15 cts.

SALT LAKE CITY.

Outfall Sewer and Sewage Farm at Salt Lake City, Utah. Illustrated description of the gravity intercepting sewer and the sewage farm, which were undertaken to prevent the pollution of the Jordan River. 1,500 w. Eng News—March 18, 1897. No. 11,792. 15 cts.

SEWAGE Disposal.

Sewage Disposal. W. M. Watson. An examination of some of the systems for cleansing sewage and their inefficiency; claiming that no chemical process, without some secondary treatment, is capable of producing a sufficiently pure effluent. Ill. 2,000 w. Can, Eng—March, 1897. No. 11,570. 15 cts.

Handling Boston's Sewage. Henry G.

Young. Extracts from a lecture before the Massachusetts Assn. No. 1, N. A. S. E. The growth of the system in Boston and the steam plant necessary to handle it. 1,800 w. Bos. Jour of Com—March 27, 1897. No. 1,922. 15 cts.

The Utilization of Town Sewage. Alderman Maskery. A paper read in relation to the Peat system of town refuse utilization as adopted at Congleton. 2,500 w. San Rec—March 19, 1897. No. 11,923. 30 cts.

SEWERAGE.

New Sewerage of the City of Melbourne. Report of the Consul-General to the State Dept. Describes the conditions to be met and the work as planned. 3,400 w. San—March, 1897. No. 11,490. 45 cts.

SEWERS.

Concrete Monolithic Sewers of Wilmington, Del. T. Chalkley Hatton. Illustrated description. 1,500 w. Eng. Rec—March 6, 1897. No. 11,456. 15 cts.

Sewers for Small Cities. Alfred E. Phillips. Considers some general propositions applicable to all cases, that should be given weight in planning a system, with hints as to the best method of carrying out the work. 4,300 w. Wis Eng—Jan., 1897. No. 11,853. 45 cts.

STREETS AND PAVEMENTS.

BRICK.

A new Testing Machine and the Cross-Breaking Test of Vitrified Paving Brick. F. F. Harrington. Describes the testing machine designed by M. L. Holman and gives the results of an investigation of the cross-breaking test of paving brick. Ill. 4,000 w. Jour Assn of Engng Soc—Jan., 1897. No. 11,786. 30 cts.

Standard tests for Paving Brick. Almon D. Thompson. Exceptions to conclusions reached by the committee of the Nat Brick Mfr Assn. 1,700 w. Munic Engng—April, 1897. No. 11,995. 30 cts.

Supplemental Specifications by the Paving Brick Commission. Supplemental to the report of the commission heretofore published. Specifications for tests with table. 1,400 w. Munic Engng— April. 1897. No. 11,996. 30 cts.

PAVING.

Granite-Asphalt. (Le Granite-Asphalte.) A combination of asphalt and crushed granite, furnishing a paving having all the advantages of asphalt, without its slipperiness. 1,200 w. Le Génie Moderne—Feb. 15, 1897. No. 11,744. 30 cts.

ROAD Making.

Tests of Resistance of Vehicles on Common Roads by the U. S. Department of Agriculture. Report of a series of experiments to determine the value of tractive force in the case of vehicles and roads now in use. 1,300 w. Eng News—March 18, 1897. No. 11,791. 15 cts.

STREET Cleaning.

Street Cleaning in Paris and Berlin. Robert Grimshaw. Describing plants, personnel and methods of European street cleaning department. 3,800 w. Eng Mag—April, 1897. No. 12,054. 30 cts.

VIENNA.

Street Improvements in the City of Vienna. (Ueber die Reguliring der innern Stadt von Wien.) A plan submitted by Architect Lotz for the improvement of the central portion of Vienna by cutting new streets and widening old ones. An excellent study in municipal improvement. 1,500 w. and map. Zeitschr d Oesterr Ing u Arch Ver—Feb. 19, 1897. No. 11,727. 30 cts.

WOOD Paving.

Hardwood Pavements in Sydney, New South Wales. R. W. Richards. Abstract of paper read before the English Assn. of Munic. and Co. Engs. on the latest experience with hardwood pavements in Sydney. Favorable to its use. 1,000 w. Eng News—March 18, 1897. No. 11,794. 15 cts.

A Hygenic View of Wood Paving. Translated for Hardwood from L'Echo Forestier. A. Petsch. Thinks wood paving has not interfered with sanitary conditions. 900 w. Sci Am Sup. March 20, 1897. No. 11,672. 15 cts.

Maintenance of Wood Pavement in European Cities. Robert Grimshaw. Brief reports from London, Paris and Germany. 500 w. Munic Engng—April, 1897. No. 11,994. 30 cts.

WATER SUPPLY.

BROOKLYN.

The report of the Manufacturers' Associaton of Kings and Queens Counties on the Brooklyn Water Supply. Abstract of report dealing with the future and immediate needs of the city, advocating the use of meters, the establishment of a permanent analytical laboratory, and recommendations for increasing the supply. Also editorial. 1,400 w. Eng Rec—March 27, 1897. No. 11,898. 15 cts.

CAMBRIDGE, Mass.

Water-Works of Cambridge, Mass. Illustrated description of the works, which are being extensively enlarged, so as to increase the supply, pressure and pumping capacity. 1,800 w. Fire and Water—March 20, 1897. No. 11,845. 15 cts.

CONCORD, N. H.

Concord, N. H. Water Department. Illustrated description of a plant that has been in use about four years and is satisfactory in every respect. 1,200 w. Fire and Water—March 13, 1897. No. 11,651. 15 cts.

HUNGARY.

Arad Water-Works, Hungary. Illustration and brief description, with table giving the return of the filters for Oct., 1895. 800 w. Ind Engng—Jan. 30, 1897. No. 11,464. 45 cts.

METERS.
The progress of Water Meterage. Part first calls attention to the rapid progress made in the introduction of meters and gives report from Harrisburg. 1,200 w. Fire and Water—March 6, 1897. Serial, 1st part. No. 11,477. 15 cts.

NEW YORK.
The Future Water Supply of New York. An interview with Gen. Duane, President of the Croton Aqueduct Commission. 1,000 w. Fire and aWter—March 20, 1897. No. 11,846. 15 cts.

RESERVOIR.
The Repairs to the Queen Lane Reservoir, Philadelphia, Pa. Gives investigations made to determine the power of asphalt to resist percolation of water, as some of the work failed to give satisfaction. 1,300 w. Eng Rec—March 27, 1897. No. 11,899. 15 cts.

TORONTO.
Water Supply of Toronto, Ont. An account of the cost of the water supply works, now owned by the city, and of an accident causing the breakage of a five-foot and a four-foot pipe. Ill. 1,000 w. Fire and Water—March 27, 1897. No. 11,924. 15 cts.

WATER Supplies.
See Civil Engineering, Irrigation.

WATER Works.
Valuation of Water-Works Property. Wynkoop Kiersted. Discusses the determining power of water-works property. The difference between cost and value; the various methods of valuation, &c. 7,000 w. Pro Am Soc of Civ Engs—March 1897. No. 11,882. 75 cts.

MISCELLANY.

GARBAGE.
The Garbage-Disposal System of New Brighton, N. Y. Information relating to the Brownlee crematory in use on Staten Island. 900 w. Eng Rec—March 13, 1897. No. 11,639. 15 cts.

MUNICIPAL Lighting.
See same title under Electrical Engineering—Lighting.

PAINT.
The Painter as a Sanitarian. John Dewar. Calls attention to the impurities that accumulate on the walls and ceiling, and the use of paint in restoring a more healthful condition than is possible in papered rooms. 1,600 w. Plumb & Dec—March 1, 1897. No. 11,585. 30 cts.

PUBLIC Work.
Public Work and How to Do It. I. A Boston Argument in Favor of Direct Municipal Performance. Sylvester Baxter. II. Toronto and Chicago Compared in the Matter of Street-Cleaning by Contract. George E. Hooker. Part 1st presents the evils of the contract system, with comparative costs of public and private contract, etc. Part 2d gives highest praise to the direct labor system of Toronto and severely criticises the contract system in Chicago. Ill. 4,500 w. Rev of Rev—April, 1897. No. 11,998. 30 cts.

PUMPING.
Comparative Cost of Steam and Electric Pumping in New Orleans, La. The results of a study detailed estimates which have led B. M. Harrod, chief engineer of the Drainage Commission, to report in favor of a central power station with electrical transmission in carrying out a drainage scheme for this city. 1,000 w. Eng Rec—March 20, 1897. No. 11,803. 15 cts.

PURIFICATION.
See same title under Municipal Engineering—Sewerage.

SANITATION.
European Sanitary Engineering. James H. Fuertes. Describes the arrangement and operation of the refuse-disposal plant at Cambridge, Eng. Ill. 1,300 w. Eng Rec—March 20, 1897. Serial. 1st part. No. 11,804. 15 cts.

The Evolution of Sanitation in Relation to the Plumber. John Glaister. Extract from a paper read in Edinburgh. Calls attention to the problems that arose in the evolution of man from the barbaric to the civilized state, and to the main points to be attended to in sanitary plumbing. 2,000 w. Plumb & Dec—March 1, 1897. Serial. 1st part. No. 11,584. 30 cts.

RAILROAD AFFAIRS.

NEW CONSTRUCTION.

CONSTRUCTION.
Mistakes and Improvements in Railroad Construction. George H. Paine. Showing that the tendency in maintenance of way work is towards more subsoil tile drains, abundance of good stone ballast and immovability of track (Ill). 4,500 w. Second paper. Eng'ng Mag—April, 1897. No. 12,050. 30 cts.

EAST Coast.
The Lancashire, Derbyshire and East Coast Railway. Illustrated description of the line and some of the constructive works, with information concerning the road. 2,200 w. Eng Lond—March 12, 1897. No. 11,820. 30 cts.

EGYPT.
Railway Development in Egypt. Information from the report of Lord Cromer, relating to railway extension. 1,700 w. Trans—Feb. 26, 1897. No. 11,524. 30 cts.

GAGE.
Fixed Point on the Mixed Gage. J. E.

A suggestion to overcome difficulties arising from the use of the mixed gage. Ill. 1,800 w. Ind Eng'ng—Feb. 13, 1897. No. 11,814. 45 cts.

GREAT Western Ry.

The Progress of the Great Western Railway. An account of the schemes and projects by which a great improvement in the traffic is to be accomplished. 3,300 w. Eng Lond—March 12, 1897. No. 11,818. 30 cts.

KOREA.

Railroads in Korea. J. Henry Dye. Information concerning the prospects for railroad building, and the various lines under consideration. 3,500 w. RR Gaz—March 12, 1897. No. 11,555. 15 cts.

TRACK.

Track Elevation at Brockton, Mass; N. Y. N. H. & H. R. R. Illustrated description of an interesting example of work. 1,200 w. Eng News—March 25, 1897. No. 11,876. 15 cts.

TRACKS.

Depression of the Tracks of the Boston & Albany RR., at Newton, Mass. Illustrated description of the depression of the four-track line of the Boston & Albany, below the normal surface of the ground. 900 w. Eng News—March 18, 1897. No. 11,790. 15 cts.

MAINTENANCE OF EQUIPMENT.

AXLES.

Revolution-Testing Machine for Axle Material—Pennsylvania Railroad. Describes and illustrates an interesting device for testing the effect of reversal of stress upon metals designed for the purpose of determining the behavior of material used for axles, when subjected to rapidly repeated alternating strains. 8,000 w. Ry Mas Mech—March, 1897. No. 11,461. 15 cts.

BOLSTERS.

Finding the Stresses in Trussed Bolsters. Explanation of the graphical method, with diagrams, showing how clearly this method brings out the result of the combination of various assumptions. 1,000 w. Ry Mas Mech—March, 1897. No. 11,460. 15 cts.

CAR.

Standard Twin-Hopper Gondola Car—New York Central and Hudson River Railroad. Illustrated description of a car considered the proper thing for the coal traffic of one of the most important systems. 800 w. Loc Engng—March, 1897. No. 11,463. 30 cts.

Steel Hopper Car of 100,000 Lbs. Capacity—Pittsburg, Bessemer and Lake Erie Railroad. Illustrated description of car especially intended to carry ore from the Lake Erie terminal to Pittsburg. 2,500 w. RR Car Jour—March, 1897. No. 11,540. 15 cts.

COAL.

Efficiency of Coal Consumption in Railway Practice. Herbert Wallis. Extract from the president's address at the meeting of the Cannadian Soc of Civ Engs. Some facts about fuel in its relation to locomotive steam practice, especially coal. 2,200 w. Can Eng—March, 1897. Serial, 1st part. No. 11,566. 15 cts.

COUPLER.

Some of the Curiosities of the Car-Coupler. Illustrated description of 20 couplers out of the 6,500 forms in the Patent Office. None of those shown have been really used. 1,600 w. RR Gaz.—March 12, 1897. No. 11,559. 15 cts.

CRADLES.

Rolling Cradles for Light Railways. C. S. Du Riche Preller. Results of the writer's inspection of several typical rolling-cradle installations, notably in Southern Germany and Switzerland. Ill. 3,500 w. Engng—March 19, 1897. No. 11,904. 30 cts.

HEADLIGHT.

The Pyle National Electric Headlight. Illustrated description of the essential features. 1,000 w. RR Gaz—March 12, 1897. No. 11,554. 15 cts.

LOCOMOTIVES.

Corliss Valve Gear for Locomotive Engines. M. E. Polonceau. Notes and summarized translation from Les Annuales des Mines. The writer has made use of a system of four Corliss valves for locomotives. This system is explained and its advantages stated. 2,000 w. Engng—Feb 26, 1897. No. 11,504. 30 cts.

Details of Eight-Wheel Locomotive—Illinois Central Railroad. Illustrated detailed description, with sections, plan and elevations of frames. 900 w. Ry Rev—March 13, 1897. Serial, 1st part. No. 11,665. 15 cts.

Details of the Compound Mastodon Locomotives for the Northern Pacific Railroad. Detail drawings, with description. 2,000 w. Am Eng & RR Jour—April, 1897. No. 12,001. 30 cts.

Early Engines of Stephenson and Company. Clement S. Stretton. Historical account, with illustrations and list of engines built from 1824 to 1833. 1,200 w. Ry Wld—March, 1897. No. 11,603. 30 cts.

European Locomotive Frames. Robert Grimshaw. Illustrated description of frames used in European locomotive practice. 1,000 w. Ry Mag—Feb, 1897. No. 11,472. 30 cts.

Standard South-Western Locomotives. Illustrated detailed description. 1,500 w. Ry Wld—March, 1897. No. 11,600. 30 cts.

The Hagans Locomotive Engine. (Hagans Locomotive.) (An illustrated description of a new type of eight-driver locomotive, without trucks and with flexible wheel base. 1,500 w.) Glaser's Annalen—Feb. 15, 1897. No. 11,715. 30 cts.

LOCOMOTIVE Performance.

Some Questions of Locomotive Per-

formance. Summary of editorial in the Engineer, London, with reply from Mr. Vawclain. 3,000 w. RR Gaz—March 19, 1897. No. 11,692. 15 cts.

PAINTING.

Painting Freight Cars by Compressed Air. Charles E. Copp. Abstract of a report read at meeting of New England RR Club, the result of a visit to Pittsburg for the purpose of investigating the subject. 1,000 w. RR Car Jour.—March, 1897. No. 11,542. 15 cts.

Pneumatic Painting Criticized. Gives reason for objecting to this method of painting. 900 w. RR Car Jour.—March, 1897. No. 11,541. 15 cts.

ROCKET.

George Stephenson's Rocket. A historical difficulty explained. Ill. 600 w. Sci Am Sup—March 13, 1897. No. 11,536. 15 cts.

SWIVEL Truck.

The Action of the Krauss Swivel Truck on Curves (Die Einstellung des Krauss-'schen Drehgestelles in Krümmungen. Von Borries.) An examination of the unequal rail pressure of swivel trucks upon curves of different radii. 1,000 w. Glaser's Annalen—Feb. 15, 1897. No. 11,716. 30 cts .

VALVES.

The Schenectady Intercepting and Exhaust Valves. Engravings, with description of the intercepting compound locomotives, as designed by Mr. Pitkni and Mr. Sague for the Northern Pacific twelve-wheeler. 1,000 w. RR Gaz.—March 26, 1897. No. 11,887. 15 cts.

MAINTENANCE OF WAY.

BRIDGE Extension.

See same title under Civil Engineering —Bridges.

BRIDGES.

Standard Specifications for Metal Bridges, Boston and Maine RR. An abstract of some of the more novel features of these specifications. 1,100 w. Eng News—March 18, 1897. No. 11,796. 15 cts.

CURVES.

Adjustment Curves William G. Raymond. From a forthcoming text-book, "The Elements of Railroad Engineering." The theory and practice of curves in railroading. Treats of the two general methods of providing for gradual entry to a curve. 1. The three-centre compound curve. 2. The transition curve, or spiral. 4,500 w. Polytechnic—March 27, 1897. No. 11,946. 15 cts.

The Elevation of the Outer Rail of Railway Curves. Wm. G. Raymond. Abstract of a paper in the last issue of "The Polytechnic" discussing the proper amount of cant to give railway track on curves. 700 w. Eng News—March 25, 1897. No. 11,878. 15 cts.

STATION.

A Handsome Structure for Galveston. Illustrated description of a new depot and general office building for the Gulf, Colorado and Santa Fe. 1,000 w. Ry Age—March 5, 1897. No. 11,482. 15 cts.

Van Buren Street Suburban Station—Illinois Central RR., Chicago. Illustrated description. 700 w. Ry Rev—March 6, 1897. No. 11,502. 15 cts.

TIES.

Cedar Ties in Service. Moses Burpee. A study of the character of the wood, reasons for its failure under certain conditions, its weak points and redeeming qualities. Ill. 3,700 w. Ry Rev—March 13, 1897. No. 11,664. 15 cts.

TIMBER.

See same title under Civil Engineering —Miscellany.

TRACKS.

Undulations in Railway Tracks. P. H. Dudley. A study of the deflections of rails, the causes and remedy; the objects of permanent way construction and the success attained between New York and Buffalo, on the N. Y. C. and H. R. RR. Ill. 5,400 w. Sch of Mines Quar—Jan., 1897. No. 11,989. 45 cts.

TURNTABLES.

Some Examples of Recent Practice in Turntable Design. An examination in a general way of some of the theoretical and practical considerations which enter into turntable design and construction, with a study of the particular designs illustrated in the present number. 3,500 w. Eng News—April 1, 1897. Serial, 1st part. No. 11,705. 15 cts.

SIGNALING.

CROSSINGS.

Crossing Protection Between Electric and Steam Railways. Extract from advance sheet of report of the Railroad Commissioners of Massachusetts. A statement of dangerous conditions, with suggested remedies. 1,000 w. Ry Rev—March 27, 1897. No. 11,953. 15 cts.

ELECTRO-PNEUMATIC.

Electro-pneumatic Contact System. (Pneumatisch-elektrischer Kontakt-Apparat.) Illustrated description of the Boldt & Vogel automatic signal. An electric contact, made by the elastic depression of the rail, operates the valve of a pneumatic system of signals and switches. 2,000 w. Glaser's Annalen—March 1, 1897. No. 11,719. 30 cts.

INTERLOCKING.

Two New Interlocking Plants. Illustrated description of two plants recently installed. One at Germantown Junction, Philadelphia and Reading RR., the other at Seattle, Wash., Great Northern Ry. 800 w. Eng News—March 11, 1897. No. 11,543. 15 cts.

SIGNALLING.

Some Signal Problems. H. M. Sperry. Read befare the Railway Signalling Club, Chicago. Considers some of the prob-

lems that have not yet been satisfactorily solved, such as colors for night signals, a method of checking the operation of distant signals, &c. 2,300 w. RR Gaz—March 19, 1897. No. 11,693. 15 cts.

TRANSPORTATION.

ACCIDENTS.

Train Accidents in the United States in February. Report of accidents of the month, with classified summary. 2,000 w. RR Gaz—March 26, 1897. No. 11,886. 15 cts.

COMPETITION.

Railway Rivalry in Scotland. A statement of the competitive schemes and difficulties affecting the railroads of Scotland. 2,000 w. Engng—March 19, 1897. No. 11,907. 30 cts.

Suburban Competition. Charles J. Bates. Considers the requirements of a system that will enable lines to compete successfully with electric lines in handling traffic. 1,600 w. RR Gaz—March 12, 1897. No. 11,553. 15 cts.

EARNINGS.

Improving Railway Earnings. Tables of gross earnings in Feb. 2,000 w. Bradstreet's—March 13, 1897. No. 11,565. 15 cts.

ELECTRICITY.

Electricity on Steam Roads. Extracted from the address of Charles P. Clark before the Railroad Committee of Connecticut. Gives an account of the experiments near Boston, the successful use of the third rail system and a general discussion of the problem. 2,800 w. St Ry Rev—March 15, 1897. No. 11,612. 30 cts.

FAST Running.

Remarkable Running Achievements by Scottish Railway Companies. Record of work on the North British and Caledonian railways. 1,200 w. Trans—March 19, 1897. No. 11,934. 30 cts.

FREIGHT Rate.

An English Freight Rate Adjustment. Editorial discussion of the decision reached in a case brought before the Commission relating to an increase of 2½ per cent. on coal traffic carried to London. 1,200 w. RR Gaz—March 12, 1897. No. 11,557. 15 cts.

The Eau Claire Lumber Rate Case Editorial Examination of the controversy relating to the transportation of lumber. 1,200 w. RR Gaz—March 12, 1897. No. 11,556. 15 cts.

The Grain Rate Differentials. A discussion of the case before the Interstate Commerce Commission. The complaint that the trunk railroads make rates from the West to the seaboard cities that unjustly discriminate against New York to the benefit of other cities. A statistical table relating to flour, wheat and corn receipts and exports is given. 1,600 w. Bradstreet's—March 20, 1897. No. 11,788. 15 cts.

Hearing on New York Grain Rates. A summary of the New York argument made by John D. Kernan, with testimony of several witnesses and editorial. 3,500 w. RR Gaz—March 26, 1897. No. 11,884. 15 cts.

"LIGHTING Trains."

"Lightning Trains" on the North British Railway. Charles Rous-Martin. Detailed account of test journeys two and fro between Edinburgh and Berwick, with a diagram showing the gradient profile of the section of the line on which the running took place. 3,300 w. Eng, Lond—March 12, 1897. No. 11,817. 30 cts.

POOLING.

The Pooling of Railway Earnings. Aldace F. Walker. The differences which exist between railways and other business enterprises in the matter of determining the charges to be made are shown, the object of the railway pool explained and the method suggested for meeting the requirements of the present situation in the United States. 4,000 w. Ry Mag—Feb. 1897. No. 11,470. 30 cts.

A Pooling Law Before Congress. Discusses the bill introduced in the United States Congress by Senator Foraker, of Ohio, aiming to formulate a measure which will authorize agreements to maintain reasonable rates. 1,000 w. No. 12,009. 15 cts.

Full Text of the Trans-Missouri Freight Association Decision. 19,500 w. Ry Age—March 26, 1897. No. 11,939. 15 cts.

SPEED.

The Limits of Speed and Frequency of Trains in Tunnels. The consideration of a problem presented at meeting of N. Y. RR. Club, and left unanswered, as to the safety of running trains at 30 miles an hour, on one minute headway, through a tunnel with grades as stated. 1,200 w. RR Gaz—March 26, 1897. No. 11,888. 15 cts.

Some Studies in Speed and Accelerations of Various Motors. George L. Fowler. Investigations of the mechanical possibilities of the several methods of passenger transportation that are at present in use in the neighborhood of New York City. 3,800 w. RR Gaz—March 19, 1897. Serial. 1st part. No. 11,694. 15 cts.

MISCELLANY.

AVALANCHE.

The Avalanche at Ophie. An account of the snowslide which overwhelmed the Rio Grande Southern depot and tracks, with illustrations. 1,100 w. Ry Age—March19, 1897. No. 11,850. 15 cts.

BRITISH Railroads.

British Railroad Matters. W. M. Ac-

worth. Treats briefly of light railroads, railroad clubs, and of a new through service between London and Paris. 1,200 w. R R Gaz—March 12, 1897. No. 11,551. 15 cts

British Railways in 1896. William J. Stevens. A survey of the year's railway working and results, confined mainly to the principal English and Welsh companies. 4,200 w. Bankers' Mag, Lond—March, 1897. No. 11,563. 30 cts.

COLLISION.

See same title under Street and Electric Railways—Miscellany.

DENMARK.

Danish State Railroads. Comments on the published statistics of the past year. 700 w. R R Gaz—March 12, 1897. No. 11,558. 15 cts.

DISCIPLINE.

One Year's Experience with the Brown System of Discipline. H. S. Rearden. The Chicago, Peoria & St. Louis Railroad Co. adopted this system on Feb. 1, 1896. The success of the past year is recorded and the advantages explained. 4,800 w. Ry Mag—Feb., 1897. No. 11,471. 30 cts.

ELECTRICITY.

Electricity on the Cincinnati Southern Railway. Stephen L. Coles. Describes electric signals, lights, headlights and various devices in use on this road. Ill. 2,400 w. Elec Rev—March 10, 1897. No. 11,493. 15 cts.

EMPLOYEES.

Relations Between Railways and Their Employees. Report of a special committee of the Am. Soc. of Ry. Supts. Includes the selection of employees, discipline, systems of relief, &c. 1,500 w. Ry Rev—March 20, 1897. No. 11,851. 15 cts.

INDIA.

Railway Travel in India. Allan Forman. An account of travel in this country which indicates very comfortable accommodations; also some reference to interesting sights. 1,400 w. Ry Age—March 12, 1897. No. 11,631. 15 cts.

STRIKE.

See "The Collapse of the Northeastern Strike," under Economics and Industry—Labor.

TUNNEL.

See same title under Civil Engineering—Miscellany.

TUNNEL Ventilation.

Ventilation Difficulties in the Arlberg Tunnel. Abstract from an article in "Revue Generale des Chemins de Fer." Trouble from the use of coal and coke were largely overcome by the use of petroleum for steam producing. 1,100 w. Eng News—March 18, 1897. No. 11,795. 15 cts.

STREET AND ELECTRIC RAILWAYS.

AIR Cars.

Cost of operating Air Cars in New York City. Edward E. Pettee. A statement of the actual operating expenses for seven months, through extreme ranges of temperature. Ill. 2,300 w. Com Air—March, 1897. No. 11,993. 15 cts.

BRAKES.

Brake Rigging for Electric Cars. C. F. Uebelacker. Calls attention to some of the more prominent conditions which brake rigging in general must meet. Ill. 3,500 w. St Ry Jour—March, 1897. No. 11,698. 45 cts.

CABLE.

System of Cable Traction, Mollard & Dplac (Systeme de Remorguage Funiculaire, Mollard et Dulac). A combined cable and electric trolley system, by means of which electric cars carry a grip and are hauled up steep inclines by continuous running cable. 7,000 w. La Revue Technique—Feb. 25, 1897. No. 11,753. 30 cts.

CAR Lighting.

See same title under Electrical Engineering, Lighting.

COLLISION.

Report on a Grade Crossing. Collision Between a Railway Train and an Electric Car. Account of accident taken from an advance copy of the report on Street Railways, issued by the Board of RR Commissioners of Massachusetts. The collision was in the town of Somerset. The electric car was demolished and the train derailed. 2,400 w. Eng News—March 11, 1897. No. 11,545. 15 cts.

CONSTRUCTION.

The Columbia and Maryland Railway. S. W. Huff. A sketch of some of the plans and problems encountered in the construction of this railway. Part first states the conditions to met, and the special form of three-wire system used. Ill. 1,900 w. St Ry Rev—March 15, 1897. No. 11,614. 30 cts.

CURVES.

Dead Man's Curve. A discussion of means to overcome the danger at the corner of Fourteenth st. and Broadway, New York. Recommends the changing of motive power from cable to electricity. 1,000 w. Elec Wld—March 6, 1897. No. 11,500. 15 cts.

ELEVATED Railway.

A new form of Elevated Railway Construction (Ein Neues Hochbahn System.) This appears to be practically the well-known "bicycle" system, with single rail below and guide rail above, revived in Geremany. 1,000 w. Zeitsch d Oesterr. Ing u Arch Ver—March 5, 1897. No. 11,736. 30 cts.

GEARS.
The Life of ears. H. S. Cooper. Reasons for the determination to use only a rawhide pinion and a metal gear. 1,500 w. St Ry Jour—March, 1897. No. 11,776. 45 cts.

GERMANY.
Electric Street Railways (Elektrische Strassenbahnen. Dr. Gustav Rasch). A discussion of general principles of installation, including the combined overhead and underground system, together with the use of storage batteries. 5,000 w. Zeitschr d Ver Deutscher Ing—Feb. 6, 1897. No. 11,702. 30 cts.

JUNGFRAU.
The Jungfrau Railway. Brief account of this unique railway, with perspective view, profile and geological section. 1,800 w. Ry Wld—March, 1897. No. 11,602. 30 cts.

MAIL Service.
Mail Service on Street Railways. Statements regarding the growth and improvement of the service, which is said to be not a source of great financial gain. 1,200 w. St Ry Rev—March 15, 1897. No. 11,615. 30 cts.

OVERHEAD Railway.
Framework ofr Overhead Railways (Charpente pour Chemins de Fer Aériens). Design for overhead truss for cars suspended beneath the rails. 1,000 w. La Revue Technique—March 10, 1897. No. 11,759. 30 cts.

PARIS.
Claret-Vuilleumier Tramway of Paris. Illustrated description of an electric line with underground connections, of peculiar construction. 900 w. W Elec—March 13, 1897. No. 11,580. 15 cts.

PLEASURE Resorts.
Amusement Features at Willow Grove Park, Philadelphia. Description, with two-page engraving of the attractive features of a pleasure park near Philadelphia, constructed for the Union Traction Co. 3,200 w. Eng News—March 11, 1897. No. 11,544. 15 cts.

POWER Station.
The Dorchester Power station of the West End St Ry Co., Boston, Mass. H. W. Weller. Illustrated detailed description. 2,500 w. Elec Eng—March 24, 1897. No. 11,863. 15 cts.

Notes on Electric Railway Power Stations. Henry A. Lardner. Stations operating five, twenty-five and one hundred cars respectively are considered. 3,000 w. Wis Eng—Jan., 1897. No. 11,856. 45 cts.

The New Power Station of the Chicago City Railway. Illustrated detailed description of the new station at Forty-ninth street and Oakley avenue. 3,000 w. St Ry Jour—March, 1897. No. 11,777. 45 cts.

RAILS.
The Solution of an Important Street Railway Problem. The difficulty of using the two kinds of rails used in the cities and for suburban roads, without loss of speed or danger. Solved by a design of truck, and successfully tested. Ill. 800 w. St Ry Rev—March 15, 1897. No. 11,618. 30 cts.

RAPID Transit.
Rapid Transit in New York. G. Lindenthal. Discusses the conditions likely to affect the financial prospects of any new rapid transit railroad and suggests a plan that would give relief to suburban and city pasengers from the north. 1,200 w. RR Gaz—March 26, 1897. No. 11,883. 15 cts.

Some Considerations on "Rapid Transit." Editorial comment called forth by the paper of W. L. Derr, presenting some of the strict conditions which must govern any intelligent study of this subject. 1,500 w. RR Gaz—March 19, 1897. No. 11,695. 15 cts.

RECONSTRUCTION.
Reconstruction of Cable Track in Cincinnati. Bert S. Baldwin. Description of method of reconstruction which progresses while both electric and cable cars are operating. 1,500 w. St Ry Rev—March 15, 1897. No. 11,616. 30 cts.

REPAIRS.
Some Statistics on the Life of Brake Shoes, Gears, Pinions and Trolley Wheels. Particulars given are the result of inquiry instituted among a few companies. 1,300 w. St Ry Jour—March, 1897. No. 11,700. 45 cts.

SAN FRANCISCO.
Mill Valley andMount Tamalpais Scenic Railway. Brief description of road, with illustrations of the mountain-climbing locomotives. 400 w. Loc Engng—March, 1897. No. 11,462. 30 cts.

SHOPS.
Shops of the Cincinnati Street Railway Company. Illustrated detailed description. 1,800 w. St Ry Rev—March 15, 1897. No. 11,617. 30 cts.

SNOW Plow.
A Pneumatic Snow Plow. Illustrated description of a pneumatic snow plow used on the Atlanta Consolidated Street Railway. 500 w. St Ry Rev—March 15, 1897. No. 11,613. 30 cts.

SPEED.
Speed Ordinances. Replies to a letter of inquiry sent out for the purpose of learning what restrictions, if any, are put upon the speed of electric and cable cars in the principal cities of the United States. 1,700 w. St Ry Jour—March, 1897. No. 11,699. 45 cts.

SYRACUSE, N. Y.
Street Railway System of Syracuse, N. Y. Illustrated detailed description. 6,500 w. St Ry Jour—March, 1897. No. 11,697. 45 cts.

TORONTO.

Toronto Harbor and the Proposed Island Railway. Report of A. B. Ross, giving an estimate of cost of bridging the gap, with discussion of other objections. 2,200 w. Can Eng—March, 1897. No. 11,571. 15 cts.

TRACK.

Some Notes on Electric Street Railway Track. W. M. Camp. Points out present tendencies in street railway track construction as regards the types of materials used, the manner of putting them together in the track, and the methods of ballasting the track and the materials used therein. 4,200 w. Wis Eng—Jan., 1897. No. 11,857. 45 cts.

TRACTION.

Discussion of the Berlin Tramway. (Mittheilungen über die bei der Grossen Berliner Pferdeeisenbahn gemachten Eefahrurgen, &c.) An enegetic discussion before the German Railway Society as to the merits of various systems of propulsion; electric overhead and underground, also compressed air. 1 plate of rail joints. 6,000 w. Glaser's Annelen—March 1, 1897. No. 11,718. 30 cts.

Electrical Equipment of the Alley "L," Chicago. To be changed from steam to electricity, the road being divided into 18 sections, each about half a mile in length, each section to be supplied with current by a separate feeder. 1,000 w. W Elec—March 27, 1897. No. 11,902. 15 cts.

Some Opinions Regarding Electricity on the New York Elevated Railways. Opinions of William J. Fransioli and Sidney H. Short, on the feasibility of substituting electric for steam power and the advantages to be expected from the change. 1,500 w. Elec Wld—March 6, 1897. No. 11,501. 15 cts.

The Application of Mechanical Traction Upon Tramways. (Application des Moteur Mécaniques a la Traction des Tramways.) A general discussion of the subject, taking up seriatim steam, fireless locomotives and compressed air. Two articles of a series. 5,000 w. La Revue Technique—Feb. 25 & March 10, 1897. No. 11,755. 60 cts.

The "Simplex" Conduit System of Electrical Traction. Illustrated description of a model line of tramway laid at Prescott, Lancashire. 2,500 w. Elec Eng, Lond—March 12, 1897. No. 11,839. 30 cts.

TRAMWAYS.

The Construction and Operation of Electric Tramways. (Ueber den Bau und Betrieb elektrischer Bahnen.) A descriptive address by Herr Prasch upon the general details of electric tramway construction. Two articles. 8,000 w. Zeitsch d Oesterr Ing u Arch Ver—Feb. 26 & March 5, 1897. No. 11,730. 30 cts.

TRUCK.

The American Electric Truck. W. E. Partridge. A description of the truck as found in the best American practice. 1,000 w. Ry Wld—March, 1897. No. 11,601. 30 cts.

BOOKS OF THE MONTH

Hiscox, Gardner D., M. E. Gas, Gasoline, and Oil-Vapor Engines. A New Book Descriptive of Their Theory and Power, and Illustrating Their Design, Construction, and Operation for Stationary, Marine, and Vehicle Motive Power. Norman W. Henley & Company, New York. 1897. Cloth, $2.50.

We desire to enter a protest against term "explosive motor," of which the the author makes a free use. But, having made this demur, we are free to say that the treatise seems well conceived and the task well executed. The introduction gives a historical sketch of the progress in the theory and practical construction of this class of motors, which is followed by a chapter on the theory of the gas and gasoline engine. In the third chapter, which deals with the utilization of heat and efficiency, the principle is laid down that "the utilization of heat in a gas engine is mainly due to the manner in which the products entering into combustion are distributed in relation to the movement of the piston." The efficiencies of the earlier and later types of engines are then reviewed. Twenty-four chapters follow, and a final one deals with United States patents on gas, gasoline, and oil engines. In the discussions of the various topics which fill the book,—an octavo of 350 pages,—the practical side is mainly dealt with. The work is handsomely printed and copiously illustrated.

"The Electrician" Electrical Trades Directory and Handbook for 1897 (Fifteenth Year). "The Electrician" Printing and Publishing Company, London. 1897. Cloth. 7s. 6d.

This work has been revised and corrected up to January 31, 1897, and, in addition to the usual large amount of useful trade information ordinarily comprised in it, it contains for the first time: (1) a large sheet table, giving technical particulars of the railways and tramways of the United Kingdom; (2) regulations regarding the free supply of incandescent electric lamps; (3) the new regulations of the London county council for electric meter testing; (4) a number of useful tables relating to water power, British coal, dry saturated steam, hydraulic heads, feed-water heating, rope gearing, etc.; (5) an interesting historical sketch of the international telegraph bureau at Berne; (6) the Buda-Pesth (1896) revision of the international telegraph tariff; (7) a new section of the directorial division, dealing with Japan and the Far East, which contains the names, professions, and addresses of all persons in those parts of the world associated with electrical work; (8) a carefully-compiled sheet table, giving exhaustive particulars of the electricity-supply stations of the United Kingdom, (to February, 1897); (9) a revised digest of the law of electric lighting; (10) ditto of the law of electric power (for traction purposes); (11) the latest revised rules of British, American, Canadian, French, and German fire insurance corporations, relating to electrical risks. All the old and well-known features of the book are retained, but are rigidly brought up to the date of publication.

Bailey, G. H., D.Sc., Ph.D. The Tutorial Chemistry. W. B. Clive, London; Hinds & Noble, New York, 1877. Cloth, $1.00.

What we have said elsewhere in terms of general approval of the University Tutorial Series sufficiently implies our estimate of the value of this treatise on chemistry. Although a small treatise upon a very large subject, it has sufficient space to present a systematic outline of chemistry, so far as it relates to the non-metals. Chemical theory is only slightly discussed, as the book is for students in the earlier stages of progress. A union of experiment, observation, and inference is combined with such descriptions of experiments as will, under the guidance of a teacher, render it useful in the laboratory.

Le Van, William Barnet. The Practical Management of Engines and Boilers. Including Boiler Setting, Pumps, Injectors, Feed-Water Heaters, Steam-Engine Economy, Condensers, Indicators, Slide Valves, Governors, Steam Gages, Incrustation and Corrosion, etc. A Practical Guide for Engineers and Firemen and Steam Users Generally. The Philadelphia Book Company, Philadelphia. 1897. Cloth. $2.

Mr. Le Van is well and widely known as a consulting steam engineer, being a mem-

ber of the American Society of Mechanical Engineers and of the Franklin Institute, which are doing more for the advancement of mechanical engineering than all the other technical societies in the United States. The title suggests quite a wide range of topics; the size of the volume indicates that an exhaustive treatment has not been attempted. The book, which embodies the author's experience of more than forty years, is eminently practical, covering a large number of points for which an engineer or fireman would like to have a ready-reference book. It is well indexed.

Hogg, Prof. Alex. M. A., Superintendent of Schools, Fort Worth. John P. Morton & Company, Louisville. 1897. Paper.

This consists of an address delivered, presumably at Fort Worth, in 1885. Many changes have taken place since the address was delivered, and to the 24 pages which it occupies are added 104 pages of statistical and general information of progress in railroading since the year named. A statement of notable gifts and bequests to educational institutions by eminent railroad men forms a portion of this collection of addenda. A section is also devoted to fast runs, and some interesting biographical sketches are supplied.

Johnson, John A. South America, Its Resources and Possibilities. Agricultural, Pastoral, and Dairy Resources Described. M. J. Cantwell, Madison, Wis. 1897. Paper. Copies supplied by the Gisholt Machine Company on application.

The author of this little book is president of the Fuller & Johnson Mfg. Company, and also of Gisholt Machine Company, of Madison, Wis., and he was a member of the delegation of the National Association of Manufacturers that visited South America last year in the interest of international trade. The work is in two parts, the first part comprising a series of letters written from South America, describing the resources of Brazil, Argentina, and Uruguay, and proposing plans for a more extended commerce with those countries. Part second contains suggestions of lessons that may be drawn from the experiences and conditions of the people.

West, Thomas D. Metallurgy of Cast Iron. A Complete Exposition of the Processes Involved in Its Treatment, Chemically and Physically, from the Blast Furnace though the Foundry to the Testing Machine. Fully illustrated. First edition. The Cleveland Printing and Publishing Company, Cleveland Ohio. 1897. Cloth.

The author of this treatise is doubtless the highest authority in the United States upon the metallurgy of cast iron. He has, in our opinion, done more to advance the art of iron-founding than any other man of the period. He is not only a thoroughly practical moulder and foundryman, but his educational and literary qualifications, exemplified in his contributions to the literature of cast iron, have been recognized by prominent societies and associations of which he is a member. His high reputation is well sustained by the present publication, which covers the entire ground, as proposed in the title, in a masterly manner. Foundrymen who do not possess the information presented in this able treatise must fall behind the age in the theory and practice of their art, and, probably in their struggle with competitors.

BOOKS RECEIVED.

Interstate Commerce Commission. Eighth Annual Report on the Statistics of Railways in the United States for the Year Ending June 30, 1895. Prepared by the Statistician to the Commission. Government Printing Office, Washington, D. C. 1896. Cloth.

Mac Cord, Prof. C. W., Sc. D. (a) A Curious Mechanical Movement. (b) Olivier Models Remodeled. (c) The Helical Convolute, or Single-Curved Surface with a Helical Directrix. Pamphlets, reprinted from *The Stevens Indicator*. Paper.

Jackson, Prof. Dugald C. Mem. W. S. E. The Equipment of Manufacturing Establishments with Electric Motors and Electric Distribution. Pamphlet, Reprinted from Translations of the Western Society of Engineers. Paper.

Wallis-Tayler, A. J., C. E. Bearings and Lubrication; A Handbook for Every User of Machinery. Imported by D. Van Nostrand Co. New York. Cloth, $1.50.

Annotated Bibliography of Fine Art; Painting, Sculpture, Architecture, Arts of Illustration, and Illustration, by Russell Sturgis; Music by Henry Edward Krehbiel. Edited by George Iles. Published for the American Library Association Publishing Section, by the Library Bureau, Boston. (146 Franklin street); New York (280 Broadway); London (10 Bloomsbury street, W. C.).

Annual Report of the Minister of Mines for the year ending 31st December, 1896. Being an Account of Mining Operations for Gold, Coal, etc., in the Province of British Columbia. Richard Walfenden, Victoria, B. C. 1897. Paper.

NEW CATALOGUES AND TRADE PUBLICATIONS.

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

The Farrel Foundry and Machine Co., Waterbury, Conn., U. S. A.=(a) Leaflet describing and illustrating bicycle machinery. (b) Ditto: Hardware machinery. (d) Ditto: Silverware machinery. (e) Ditto: Tube-mill machinery. (f) Ditto: Rolling-mill machinery. (g) Ditto: Annealing and case-hardening furnaces. (h) Ditto: Hydraulic draw-benches, presses, pumps, and accumulators.

The Ball Bearing Co., Boston, Mass., U. S. A.=Catalogue (1897) of "Hub" ball and roller bearings for machine construction and line shafting.

C. M. Turnquist, Chicago, Ill., U. S. A.=Catalogue and price-list of electrical supplies.

Willis Shaw, Chicago, Ill., U. S. A.=Booklet of second-hand machinery and contractors' equipment ready to ship.

The John H. McGowan Co., Cincinnati, Ohio, U. S. A.=General catalogue of pumping machinery.

Aultman & Taylor Machinery Co., Mansfield, Ohio, U. S. A.=Catalogue, nicely printed, profusely illustrated, and bound in stiff covers (buckram). This catalogue is, in reality, an essay on steam production, in which the evolution of steam generators up to the later end-of-the-century types, including the Cahall water-tube boiler, is logically traced. This is followed by a full illustrated description of the Cahall boiler, one of the latest claimants for public favor, with details of construction, explanation of its operation, and much other interesting matter.

Henry Maurer & Son, New York.=Illustrated Catalogue for 1897. Illustrates and describes an important line of fire-proof building materials,—for example, flat and segmental hollow clay arches, partition and furring blocks, column and girder protection, roof and ceiling-blocks, fire-clay flue linings, porous terra cotta, etc.

Mason Electric Equipment Co., Chicago, Ill., U. S. A.=Circular illustrating and briefly describing a line of electric railway supplies.

Kennedy Valve Manufacturing Co., New York.=Price list (illustrated) of a line of valves manufactured by this house.

Hilles & Jones Company, Wilmington, Delaware, U. S. A.=Elegantly illustrated and printed large quarto catalogue, including recent designs for working iron and steel plates, bars and structural shapes. The cuts are tinted and printed on finest quality of coated paper with descriptive text.

New York Telephone Co., New York.=Illustrated pamphlet containing a description of the private branch exchange system of supplying New York city telephone service.

Ingersoll-Sergeant Drill Co., New York=Illustrated descriptive catalogue of high-duty air compressors, in a variety adapted to cover all the uses to which compressed air can be applied, with dimension tables and other data.

Westinghouse, Church, Kerr & Company, New York, Boston, Pittsburg, and Chicago.=Pamphlet entitled "Refrigeration." Illustrates and describes the refrigerating apparatus manufactured by this company. Elegantly printed, and also containing illustrations of successful installations.

The Clonbrock Steam Boiler Company, Brooklyn, N. Y., U.S.A.=Catalogue for 1896 illustrating and describing the (patented) Morrin "Climax water-tube safety boiler."

The Garvin Machine Co., New York.=Illustrated catalogue and price-list of an extensive line of machine tools, and of special labor-saving machines for bicycle construction.

The Detroit Lubricator Co., Detroit, Mich., U.S.A.=(*a*) Catalogue for 1897. Illustrating and describing full line of hot-water and steam radiator valves, comer valves, globe valves, etc., and giving a special description of the quick opening steam and hot-water valves made by this company, with a statement of their advantages. (*b*) Leaflet, illustrating and describing the improved standard stationary engine lubricator.

The Lehigh University, South Bethlehem, Pa., U.S.A.=Course in Electrical Engineering, under direction of Alexander Macfarlane, M.A.D.Sc., LL.D.

James L. Robertson & Sons, successors to Hine & Robertson Co., New York.=Catalogue of indicators, reducing wheels, planimeters, damper regulators and other appliances for the convenient, safe and economical operation of steam-boilers and steam engines, "Eureka" packing, tools and supplies.

Automatic Friction Clutch Company, Erie, Pa., U.S.A.=Catalogue and price list describing and illustrating the automatic and friction clutch and cut-off coupling manufactured by this company.

The Hayden & Derby Manufacturing Co., New York.=Catalogue of injectors, comprising the "Metropolitan Automatic," "Metropolitan Double-Tube" and "H-D injectors."

Montgomery & Co., New York.=Leaflet, illustrating and describing the Robbins' lathe tool.

Clayton Air Compressor Works, New York, U.S.A.=Catalogue of compressed-air tools and appliances, claimed to cover the entire line, and to be the first catalogue ever published that did cover the whole field.

Boston Belting Co., Boston, New York, Buffalo, U. S. A.=Pamphlet "Suggestions for Your Benefit and Ours." Written in a conversational style, beautifully printed and illustrated on tinted paper, and containing useful hints for those contemplating alterations, improvements, increase of manufacturing facilities, or replenishing depleted stock.